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MEMOIR

OF

GEORGE ENGELMANN.

1809-1884.

BY

CHARLES A. WHITE.

Read before the National Academy, April, 1896.

BIOGRAPHICAL MEMOIR OF GEORGE ENGELMANN.

Mr. President and Members of the Academy:

Dr. George Engelmann was one of the founders of this Academy and was held in the highest esteem by all his associates. It was expected that his devoted friend and fellow-member, Dr. Asa Gray, would prepare his biographical memoir for our archives, but he, alas, also passed away before accomplishing it, and the performance of that duty was inadvertently delayed until it was assigned to me at our last stated meeting.

Because of the years that have passed since the death of Dr. Engelmann, and of the fact that most of his kindred and their family records are in a distant country, I expected more than the usual difficulty in obtaining direct and authentic biographical data. Fortunately, however, not long before his death he wrote out with his own hand a simple record of his life for his only son, Dr. George J. Engelmann. It is upon extracts from that peculiarly sacred family record that I have been permitted to base the biographical features of this memoir.* Other memorabilia have been obtained from persons who had special relations with Dr. Engelmann or with the subject of his scientific work.

Dr. Engelmann was born in the old city of Frankfurt-on-the-Main, February 2, 1809, and died in St. Louis, Missouri, February 4, 1884, having just entered his 76th year. His father,

* Four memoirs of Dr. Engelmann and numerous kindly notices of his death have already been published, which necessarily contain many of the facts which I here record. Three of the memoirs referred to are in English and one in German. The latter was written by Mr. H. A. Rattermann for "Der Deutsche Pionier," a magazine published at Cincinnati. One was written by Dr. Asa Gray for vol. xix, Proc. Amer. Acad. Arts and Sciences, and republished in the great volume of the Shaw collection of Dr. Engelmann's works. One of the others was written by Dr. Enno Sander and published as an appendix to vol. iii, Trans. St. Louis Acad. Science. The other was published by Professor C. S. Sargent in vol. iii of "Science."

Julius Bernhardt Engelmann, was a member of the Engelmann family from which for several successive generations were chosen ministers for the Reformed Church at Bacharach-on-the-Rhine. His mother, Julie Antoinette, was the only daughter of Antoinette André and George Oswald May, who in his earlier years was an artist of note at the Court of Weimar. She was descended from a family of those Huguenot émigrés who fled from the vicinity of Amiens immediately after the revocation of the edict of Nantes and settled at Offenbach, near Frankfort.

Thirteen children were born to Dr. Engelmann's parents, nine of whom reached maturity, and of whom he was the eldest. The father was a graduate of the University of Halle, and was also educated for the ministry, but he devoted his life to education, in the making of which choice he was influenced by his accomplished wife. He established at Frankfort a school for young ladies, such as were then little known, but which have since become an essential feature of female education in all enlightened countries. She was his coadjutor in that institution and its success was largely due to her management and tact. This excellent woman is affectionately remembered by her descendants as having possessed a charming disposition and a gentle but strong and vigorous character, and although the father was a worthy scion of a strongly intellectual family, George's character was largely inherited from and molded by his mother.

The education of George's earlier years was guided directly, and with great success, by his parents. As early as his fifteenth year he developed a lively interest in botany and began a systematic collection of the plants within his reach. At this early age, also, his disposition to study was such that he voluntarily devoted much of his time after the performance of his stated school duties to the study of history, modern languages, and drawing. His studies were thus prosecuted at the home of his parents until the completion of his eighteenth year, when, assisted by a scholarship founded by the "Reformed Congregation of Frankfort," he entered the University of Heidelberg, beginning his studies there in 1827.

The opportunities and stimulus for study afforded by this great university were eagerly improved, and they were happily enhanced by the congenial association of his fellow-students, among whom were Karl Schimper and Alexander Braun. With the latter especially an intimate friendship and correspondence were preserved unbroken until the death of Braun, in 1877. With Schimper also he retained friendship, although that penetrating but erratic genius after obtaining a remarkable grasp of philosophical botany and laying the foundations of phyllotaxy abandoned the subject entirely. Thus in an almost inexplicable manner he abandoned at its beginning a career of the highest promise, upon which he had entered with Braun and Agassiz and afterward Engelmann as companions.

In 1828 young Engelmann's studies at Heidelberg were interrupted by his having joined the students in a political demonstration. He thereupon left Heidelberg and entered Berlin University, where he remained two years. Thence he went to the University of Würzburg, where, in the summer of 1831, he took the degree of Doctor of Medicine. Although anticipating the order of events, it may be mentioned here that in 1882 that ancient university, *honoris et observantiæ causa*, conferred upon him its quinquagintennial diploma for eminence in medicine, surgery, and obstetrics.

His inaugural dissertation for the medical degree, which, however, was not so directly related to medicine as to philosophical botany, was published at Frankfort in 1832 under the title of De Antholysi Prodromus. It is devoted to morphology—mainly to the structure of monstrosities and aberrant forms of plants—and is illustrated by five plates of figures drawn and transferred to the lithographic stone by the author's own hand. Although produced so early in his career, this treatise is still held to be one of the most philosophical of its kind. Its subject is so directly in line with that of the little treatise on the Metamorphosis of Plants by the renowned Goethe that it was heartily welcomed by the great poet-philosopher, whose own life was then approaching its close. Having received through his correspondent, Frau Marianne von Willemer, a copy of Engelmann's treatise, Goethe made earnest inquiry after the young author, saying that he had completely apprehended his ideas concerning vegetable morphology and had shown a peculiar genius for their development. So strong was his confidence in Engelmann's ability that he offered to place in the hands of that young botanist his whole store of unpublished notes and sketches.

Soon after Engelmann's return to his home in Frankfort with his degree of Doctor of Medicine he went to Paris to continue his medical and scientific studies, and remained there during the spring and summer of 1832. There he had Braun and Agassiz as companions, and they, as he says in the record before referred to, " led a glorious life in scientific union in spite of the cholera," which was then raging in Paris. At the close of his studies in Paris he found it necessary to form some plans for his settlement in life, and, wishing to visit America, he accepted a proposition from his uncles to become their agent for the purchase of lands in the United States.

A family of his relatives had already settled in Illinois, not far from St. Louis, and, sailing from Bremen for Baltimore in September, he joined them in the following winter, and immediately began the business entrusted to him by his uncles. For the purpose of forming a correct judgment of the lands of the new country to which he had come, he made many long, lonesome, and often adventurous horse-back journeys in Illinois, Missouri, and Arkansas. He often suffered sickness and hardship upon those journeys, but he persevered until he finished all the business he had planned to do. He made much use of his scientific, as well as practical, knowledge in the prosecution of that business, doing mineralogical and geological work, but only the botanical notes which he then made were used in his subsequent scientific career.

Having completed his business engagement, Dr. Engelmann decided to establish himself in the practice of medicine in St. Louis, which he did in the autumn of 1835. During the three years that had passed since he left his native land the slender means he brought with him became exhausted and he began the the practice of his profession in absolute poverty. To furnish an office he was even obliged to part with his gun and with the faithful horse which had carried him on so many long and lonesome journeys. At that time St. Louis was little more than a frontier trading post, but Dr. Engelmann had strong faith in its future greatness, and he happily lived to see it become one of the chief cities of the nation.

Notwithstanding such an humble beginning, before four years were passed he had laid the foundation for a remarkably successful medical practice and had earned the means of making a visit to his old German home. The object of that journey was to claim the hand of his cousin, Dora Horstmann, who had been the sharer of his earlier studies as well as the stimulant to the utmost exertion for their mastery, and the hope of union with whom had been his solace during all his hardships in the new world. To her also his home-coming was the end of a long and anxious waiting, and they were married at Kreuznach on the 11th of June, 1840. This marriage was a most congenial one, and the sustaining and elevating influence of this true woman was exerted with marked effect upon the life and labors of Dr. Engelmann. It was not without pain that she left the home of her girlhood and that of her ancestors to go to a frontier town in a distant country, but she accepted with cheerfulness the frugal home her husband could offer her on the banks of the far-off Mississippi, and they sailed without delay.

Upon reaching New York, Dr. Engelmann for the first time met Dr. Asa Gray, already the most noted of American botanists, and the friendship between those two eminent men thus begun was broken only by death. This friendship is noteworthy because of the evidently beneficial effect which it had upon botanical science in America.

Upon his return to St. Louis with his young wife Dr. Engelmann immediately resumed his medical practice, and with renewed energy. Then, and long afterward, a large proportion of the inhabitants of St. Louis were of French and German-speaking families, and his familiarity with those languages, as well as with the English, gave him great advantage in extending his practice. Because of this and of his great professional ability, as the years went on he acquired a financial competence that gave him an independence of which he had little reason to hope in the years of his early struggles. Never, however, did he take advantage of his success in this respect to lessen his labors, for whenever his medical labors were relaxed his scientific work fully engrossed his attention.

The confidence which he inspired in his medical clientage was such that as he grew older he could take long vacations and resume his practice almost at will. Still, it was always difficult for him to refuse medical aid to those who sought it, and even up to the last year of his life there were old friends to whose families he was the only acceptable medical adviser and whose appeal for aid he could not refuse. Illustrating this fact, as well as the good doctor's energetic manner, his son relates the following incident: "It was a bitter, sleety winter night, when the ringing of the doorbell awoke me, and I heard an urgent call for father from the messenger of a patient. I would not arouse him, and proposed to go myself; but he had heard all, and, hurrying into his clothes, was ready to go in spite of my remonstrance 'What of the night?' he said, vexed at my interference, 'Am I already useless, to be cast aside? I would rather die in harness than rust out.' So I helped him down the icy steps, through the blinding sleet, into his carriage, and off on his mission of mercy."

He took several such vacations as I have referred to, but devoted them all to the gathering of data for his scientific work, the details of which were to be elaborated at his home. One of these vacations extended from 1856 to 1858, the greater part of the first summer having been spent in botanical work at the Harvard gardens and herbarium in companionship with his friend, Dr. Gray. Then, with his wife and young son, he visited his native land and other parts of Europe, occupying his time with scientific observation and study. In 1868 Dr. Engelmann and his wife again visited Europe for a year, the son being then in Berlin pursuing his medical studies. These visits to Europe were also the occasions of frequent and familiar personal interviews with men whose names will ever be well known to the scientific world, such as Sir Joseph Hooker, Alexander Braun, De Bary, Virchow, and others.

In the latter part of his life Dr. Engelmann had opportunities to explore large portions of his adopted country which he was unable to visit in his earlier years. In this way he was able to personally examine the living floras of the mountain region of North Carolina and Tennessee, the Lake Superior region, the Rocky Mountain region and the adjacent plains, and the Pacific Coast region. Upon those journeys, especially those in the western part of North America, he not only studied many plants that were then new to him, but he for the first time saw in the living condition plants that he himself had many years before described and named from dried specimens.

But the results of these later journeys, although very important, were only the aftermath of the great scientific harvest which he had previously gathered. The character of that harvest is shown in his published works, and remarks upon it will appear in quoted paragraphs on following pages. The manner in which it was accomplished was also remarkable, for much the greater part of his scientific work was done in the spare moments and occasional hours that he could take from an active and laborious medical practice.

While botanical investigations constituted much the greater part of Dr. Engelmann's scientific work, he always had in hand data for other investigations. For example, he began meteorological observations when he first settled at St. Louis, and personally, or by proxy during his absence, he continued them without intermission until his death—a longer period, it is believed, than that of similar observations by any one man in America. Furthermore, among the papers left at his death are voluminous and exhaustive notes upon various scientific subjects other than botany, besides copious extracts in his own handwriting from rare and valuable scientific books, all ready for use when required.

Although Dr. Engelmann never lost an iota of his inborn love and veneration for his fatherland, he was thoroughly American in all his feelings. He identified himself fully with American scientists and labored earnestly for the advancement of science in the country of his adoption. So widely had his fame extended and so highly was he esteemed by his American compeers that when it was proposed to establish our National Academy his name was one of the first to be enrolled among its founders.

He always took great pride in St. Louis, the city of his home, especially with regard to its scientific and educational interests, and he was liberal and active in their aid. He omitted no opportunity to encourage young men who manifested ability and inclination towards scientific pursuits, and many naturalists now living speak gratefully of the helping hand he was always ready to hold out to them. He was the originator of the movement to organize the St. Louis Academy of Science, and, naturally, became its first president. The membership of that academy showed their appreciation of his devotion to their interests by electing him sixteen times its president, his last election having taken place only a month before his death. He also took much interest in Washington University and delivered valuable lectures to its students on the natural sciences, not alone on botany.

Dr. Engelmann was often consulted by his fellow-citizens upon subjects of public interest, especially with regard to educational matters, but the sound advice which he from time to time gave them was not always followed, because they were not prepared to adopt plans so comprehensive as his. Still an appreciation of his devotion to public interests was shown by leading citizens in various ways. For example, the State University of Missouri honored him with the degree of Doctor of Laws, and in the year following his death his name was given to the principal professorship in the Henry Shaw School of Botany, which was then established under the auspices of the Missouri Botanical Garden and of Washington University.

Another indication of appreciation occurred when, by the generosity of Mr. Shaw and the coöperation of competent men of science, all of Dr. Engelmann's published botanical works were collected and republished in one quarto volume of 508 pages and 103 full-page plates.* Moreover, his entire herbarium, comprising 100,000 specimens, and all his library, including his notes and botanical sketches, are now in possession of the Missouri Botanical Garden, popularly known as the Shaw Garden. All this was the gift of Dr. George J. Engelmann, who, as he himself modestly says, sought to do what he believed his father would have wished.

These acts were really the final results of the profound influence which Dr. Engelmann had long exerted upon Mr. Henry Shaw, the founder of the Missouri Botanical Garden and School of Botany. A cordial friendship existed between them for many years, and it is well known that Dr. Engelmann's influence largely prevailed in shaping Mr. Shaw's plans for and the destiny of his public benefactions.

For well nigh forty years after Dr. Engelmann established himself with his young wife at St. Louis his life was unusually prosperous and free from the serious ills which fall to the lot of most men. His scientific compeers honored him, his patients gave him their unlimited confidence, his fellow-citizens recognized his sterling worth, his health was robust, and, above all, his domestic

* This volume bears the title, "The Botanical Works of George Engelmann, collected for Henry Shaw, Esq. Edited by William Trelease and Asa Gray. Cambridge, Mass. John Wilson & Son, University Press. 1887."

relations were supremely happy; but the great grief of his life came upon him in the death of his faithful wife, which occurred on January 29, 1879. His grief was, if possible, intensified by the fact that their only son was then believed to be dying from the effects of blood poisoning by virus with which the young surgeon became infected during an operation in his special field of labor.

This blow broke the spirit of the devoted husband and father, and even his robust health gave way under the crushing calamity. He turned to his beloved plants, seeking relief in study; but life and a continuance of its labors seemed to be almost hopeless. His condition changed but little during the remainder of the winter, but when in the spring Professor Sargent came with the proposition that he should join him in a journey through the forests of the Pacific Coast region he accepted it. That journey, although a difficult one for a man of his age, was of great benefit to him physically. His shattered spirit also was much revived and, among his friends, he resumed and sustained his life-long habit of cheerfulness of manner. Professor Sargent's remarks upon the effects of that journey on Dr. Engelmann are given on following pages.

In 1883 his health was so far improved that, with his son and daughter-in-law, he revisited Europe, spent some time with his kindred, and pursued certain lines of botanical study. He was so much benefited by this voyage that upon his return home he resumed some of his unfinished studies and for a time carried them on with comfort and success. But he was not deceived as to the real condition of his health. He was aware that his end was not far off, and while upon his last voyage to Europe he told his son that he expected it to come at the same time and at the same age that it came to his devoted wife, who was a few years older than he. He was entirely free from morbid sensibility, but he often referred to her in connection with this anticipation of his own death, speaking of her as if she were ever near him. The end came as he had predicted. A slight aggravation of his bodily troubles suddenly terminated the life that had been so useful, so laborious, and so honorable.

His immediately fatal condition was brought on by his habitual devotion to duty. He took a cold while sweeping a path through the snow in his garden to his never-neglected thermometers. For a few days he struggled to continue his work, but the strong spirit was at length forced to yield, and on the evening of February 2, his seventy-sixth birthday, he laid aside his plants and papers and took to his bed. Two days later he died, as it were, in harness, as had been his wish. He died, literally, with his "house set in order." So methodical were his habits that the daily and monthly records of all his work were carried on to the last. His books were carefully balanced for January and his letters all recorded in due form, even to the last one, which was written to his friend, Dr. C. C. Parry, on the day he took to his bed.

His last publication pertained to his meteorological work and consisted of a full digest of the thermometrical part of his observations for forty-seven years. I have already mentioned that he did not expect to live through the winter of 1883–'84, and this presentiment is also indicated by his having summed up his meteorological work at that time instead of waiting for the completion of half a century, for in that summary he significantly remarks, "the task then would have been problematical of accomplishment." While he speaks apologetically for not having waited longer, he shows that the results could not have been appreciably different if the observations had been continued through three years more. He had placed the manuscript in the printer's hands and had himself revised the proof-sheets, but he did not live to see the work published, the separate copies of it having reached the house on the day after his death.

Dr. William Trelease, who was appointed to the Engelmann Professorship of Botany when it was first established, has taken great pains to preserve and arrange in the Herbarium building at the Shaw Garden everything which pertains to both the published and unpublished work of Dr. Engelmann. Professor Trelease writes me as follows concerning this material, and his statements incidentally throw much light on the extraordinary industry and thorough methods of the great botanist:

"It may not be generally known that Dr. Engelmann made much fuller notes on specimens that he studied than most workers do, but such was the fact. Taking up a specimen for study, in the intervals between professional calls, he invariably sketched its characteristic details and noted its peculiarities, using for this purpose the backs of prescription blanks, several pads of which were of course always at hand. These memoranda and sketches are also preserved at the Garden Herbarium. For various reasons they possess unusual value.

"After we had reprinted his published writings, Dr. Gray, well as he had known Dr. Engelmann's methods of study, expressed great surprise at the extent and number of those notes and sketches. When a few years ago I arranged, mounted, and bound them together, I was even more surprised to see the number of detailed observations thus recorded. They embrace the facts usually carried in one's mind during the progress of a piece of research and lost, except for the generalizations based upon them and contained in the printed results of the study. *Fully 20,000 slips of this sort are thus preserved, and, as now bound up, they constitute sixty quarto volumes, varying in thickness from two to four inches.*

"We have also been fortunate enough to secure the greater part, all that are to be found, of the tentative sketches and beautifully executed and precise drawings made by Paulus Roetter for much of Dr. Engelmann's earlier work, especially the originals of some of the fine plates of the Cactaceæ of the Mexican Boundary Survey. All these are also preserved at the Shaw Garden Herbarium."

When one recovers from the surprise occasioned by this showing of Dr. Engelmann's industry, great gratification is felt that the material illustrating it has fallen into the careful hands of Professor Trelease. Besides the critical judgment of a scientist which he has exercised in the preservation of this material, he has shown a spirit of appreciative admiration for Dr. Engelmann and a desire that veneration for his name should be perpetuated.

What I have recorded on the preceding pages relates almost exclusively to Dr. Engelmann's personal history, but even so brief a memoir as this ought to contain a suitable discussion of the merits of his scientific work. It would be impossible for me to frame any words of my own which would be so descriptive and appreciative of the high character of that work as are those which his friend, Dr. Gray, has recorded. The following quoted paragraphs appear in his memoir of Dr. Engelmann, already referred to:

"Dr. Engelmann's associates and also all his published writings testify to his acuteness in observation, his indomitable perseverance in investigation, his critical judgment, and a rare openness of mind, which prompted him continually to revise his old conclusions in the light of new facts or ideas. His earliest publication, 'De Antholysi Prodromus,' is a treatise on teratology and its relations to morphology. It is a remarkable production for the time and for a mere medical student with botanical predilections. There is an interesting analysis of it in 'Nature' for April 24, 1884, by Dr. Masters, the leading teratologist of our day, who compares it with Moquin-Tandon's more elaborate Tératologie Végétale, published ten years afterwards, and who declares that, 'when we compare the two works from a philosophical point of view and consider that the one was a mere college essay, while the other was the work of a professional botanist, we must admit that Engelmann's treatise, so far as it goes, affords evidence of deeper insight into the nature and causes of the deviations from the ordinary conformation of plants than does that of Moquin.'

"Transferred to the valley of the Mississippi and surrounded by plants, most of which still needed critical examination, Dr. Engelmann's avocation in botany and his mode of work were mapped out for him. Nothing escaped his attention; he drew with facility, and he methodically secured his observations by notes and sketches, available for his own use and for that of his correspondents. But the lasting impression which he has made upon North American botany is due to his habit of studying his subjects in their systematic relations and of devoting himself to a particular genus or group of plants, generally the more difficult, until he had elucidated it as completely as lay within his power. In this way all his work was made to tell effectively.

"Thus his first monograph was of the genus *Cuscuta*, published in the American Journal of Science in 1842, of which, when Dr. Engelmann took it up, we were supposed to have only one indigenous species, and that not peculiar to the United States; but he immediately brought it up to fourteen species without going west of the Mississippi valley. In the year 1849, after an investigation of the whole genus in the materials scattered through the principal herbaria of Europe and this country, he published in the first volume of the St. Louis Academy of Science a systematic arrangement of all the Cuscutæ, characterizing seventy-seven species, besides others classed as perhaps varieties.

"Mentioning here only morphological subjects, we should next refer to his investigations of the Cactus family, upon which his work was the most extensive and important, as well as particularly efficient, and upon which Dr. Engelmann's authority is of the very highest. He, essentially for the first time, established the arrangement of these plants upon floral and carpological characters. This formidable work was begun in his sketch of Dr. Wislizenus' Expedition to Northern Mexico, in the latter's memoir of his tour, published by the United States Senate. It was followed up by his account, in the American Journal of Science, 1852, of the Giant Cactus of the Gila, *Cereus giganteus*, and allied species; by his synopsis of the Cactaceæ of the United States, published in the Proceedings of the American Academy of Arts and Sciences, 1856, and by his two illustrated memoirs upon the southern and western species, one contributed to the fourth volume of the series of Pacific Railroad Reports, the other to Emory's Report on the Mexican Boundary Survey. He had made large preparations for a greatly needed revision of at least the North American Cactaceæ, but although his collections and sketches will be indispensable to the future monographer, very much knowledge of this difficult group of plants is lost by his death.

"Upon two other peculiarly American groups of plants, very difficult of elucidation in herbarium specimens, *Yucca* and *Agave*, Dr. Engelmann may be said to have brought his work up to the time. Nothing of importance is yet to be added to what he modestly styles 'Notes on the Genus Yucca,' published in the third volume of the Transactions of the St. Louis Academy, 1873, and not much more to the 'Notes on Agave,' illustrated by photographs, included in the same volume, and published in 1875.

"Less difficult as respects the material to work upon, but well adapted for his painstaking, precise, and thorough handling, were such genera as *Juncus*, elaborately monographed in the second volume of the Transactions of the St. Louis Academy, and also exemplified in distributed sets of specimens; *Euphorbia*, in the fourth volume of the Pacific Railroad Reports and in the Botany of the Mexican Boundary Survey; *Sagittaria* and its allies, *Callitriche* and *Isoetes*, of which his final revision is probably ready for publication, and the North American Loranthaceæ, to which *Sparganium*, certain groups of *Gentiana*, and some other genera would have to be added to perfect any complete enumeration.

Revisions of these genera were also kindly contributed to Dr. Gray's Manual, and he was an important collaborator in several of the memoirs of his surviving associate and friend.

" Of the highest interest and among the best specimens of Dr. Engelmann's botanical work are his various papers upon the American Oaks and Coniferæ, published in the Transactions of the St. Louis Academy and elsewhere, the results of long continued and most conscientious study. The same must be said of his persevering study of the North American vines, of which he at length recognized and characterized a dozen species, excellent subjects for his nice discrimination and now becoming of no small importance to grape-growers, both in this country and Europe. Nearly all that we know scientifically of our species and forms of *Vitis* is directly due to Dr. Engelmann's investigations. His first separate publication upon them, 'The Grape Vines of Missouri,' was published in 1860. His last reëlaboration of the American species, with figures of their seeds, is in the third edition of the Bushberg Catalogue, published only a few months ago [1883].

" Imperfect as this mere sketch of Dr. Engelmann's botanical authorship must needs be, it may show how much may be done for science in a busy man's *horæ subsecivæ* and in his occasional vacations. Not very many of those who could devote their whole time to botany have accomplished as much. It need not be said, and yet perhaps it should not pass unrecorded, that Dr. Engelmann was appreciated by his fellow-botanists, both at home and abroad, and that his name is upon the rolls of most of the societies devoted to the investigation of nature; that he was everywhere the recognized authority in those departments of his favorite science which had interested him, and that, personally one of the most affable and kindly of men, he was as much beloved as respected by those who knew him.

" More than fifty years ago his oldest associates in this country, one of them his survivor, dedicated to him a monotypical genus of plants, a native of the plains over whose borders the young immigrant on his arrival wandered solitary and disheartened. Since then the name of Engelmann has by his own researches and authorship become unalterably associated with the Buffalo grass of the plains, the noblest conifers of the Rocky mountains, the most stately cactus in the world, and with most of the associated species, as well as with many other plants of which perhaps only the annals of botany may take account."

So deeply did the personal character of Dr. Engelmann impress those who knew him intimately that Dr. Gray, even in the foregoing critical sketch of his scientific work, could not omit the opportunity to speak tenderly of the friend who had performed it. A letter addressed to me by our associate, Professor C. S. Sargent, who knew Dr. Engelmann well, both professionally and personally, contains the following paragraphs, written in the same appreciative spirit:

"For several years previous to 1880 I had kept up a more or less active correspondence with Dr. Engelmann, but we had seldom met. In that year I was engaged in preparing the report on the forest wealth of the United States for the Tenth Census, and I asked him to join me in the journey to the Pacific coast. We traveled together in the summer of 1880 for about four months, covering the ground from Vancouver and the lower Frazer river to the Mexican boundary in southern Arizona.

"Dr. Engelmann was then rather infirm, crippled with rheumatism, and very stout. His energy, courage, and endurance were a surprise and delight to us. He never hesitated to try to get up the steepest mountains or to take long drives and rides. Generally he was badly used up at the end of a hard day, and would lie upon the ground in evident pain for an hour or two after supper, but he would rally and go to work to put up his plants of the day's collecting, working conscientiously over them for hours, sometimes when the rest of us were asleep.

"His characteristics as a traveler which struck me most forcibly were his pluck, good nature, good spirits, and good fellowship. He was always cheerful, always interesting, and always zealous. On slight acquaintance he appeared, perhaps, a little austere, but beneath this he was all good-natured jollity, and really one of the best companions I ever met. I look back upon that journey as the most interesting and profitable one I have ever made, and its success was due to Dr. Engelmann's energy, judgment, and common sense.

"As a botanist, no one who has worked in America has excelled him in patience and judgment, and no other American botanist has ever worked out harder problems or elucidated so many difficult groups of plants. All this is the more marvelous when it is remembered that botany was only his pastime. He was actively engaged all his life in professional duties as a physician, and his botany was all done at odd moments. In traveling, as at home, if he had a spare five minutes he would devote it to making a sketch or writing a note. A more industrious man never lived.

"My high estimate of Dr. Engelmann is only faintly indicated by these brief notes, but I shall always be glad to say or do anything in my power to keep green the memory of that excellent man to whom I feel deeply indebted."

Professor Sargent has improved several opportunities to honor the memory of Dr. Engelmann. Besides the memoir which he published in "Science," he dedicated to his friend volume II of his Sylva of North America, and he has added another brief sketch of his life on page 88, volume VIII of the same great work. In the memoir referred to Professor Sargent, like Dr. Gray, speaks lovingly of the prospect of enduring fame for Dr. Engelmann. He says with reference to future times: "The western plains will still be bright with the yellow rays of *Engelmannia*, and that splendid spruce, the fairest of them all, will still, it is to be hoped, cover with noble forests the highest slopes of the Rocky mountains, recalling to men, as long as the study of trees occupies their thoughts, the memory of a pure, upright, and laborious life."

Among the numerous notices of Dr. Engelmann's death which were published soon after the sad event is a peculiarly appreciative one by his friend, Dr. C. C. Parry, in volume IV of the Proceedings of the Davenport Academy of Sciences. He also was a member of Professor Sargent's party in its progress through the forests of the Pacific Coast region, and, like Professor Sargent, he regarded Dr. Engelmann's presence with them as a rare privilege. This feeling is indicated by the following remarks by Dr. Parry in the obituary notice just mentioned: "On this memorable occasion how deeply interesting to note the fresh light of manly vigor shining out of those experienced eyes as he looked for the first time upon scenes that he had so long thought over, gathering with his own hand the fruit of oak or pine that he had before only studied in the dried mummies of the herbarium! To watch the instructive processes by which he arrived at scientific results, to see the enthusiasm brightening up as he reached the solution of some deep botanical problem, was in itself a profound study and will ever remain a most cherished recollection."

Dr. Parry, like other friends of Dr. Engelmann, delighted to do him honor. While engaged in his earlier explorations he gave Dr. Engelmann's name to a peak of the Rocky mountains, and also to the picturesque cañon through which now passes the cog-wheel railroad from Manitou to the summit of Pike's peak, in Colorado.*

The kindly phases of Dr. Engelmann's character which, as we have seen, his friends like to dwell upon were more or less apparent to all his acquaintances, but there was a special manner in which his gentle nature was manifested that was apparent only to his most intimate friends, because the sphere of that manifestation was wholly domestic. This matter has already been incidentally referred to, but, although of a private nature, it is well to make more explicit mention of it here because it relates to one of the most important features of his personal character—one which greatly influenced the more obvious acts of his life. I refer to his constant and loving devotion to his noble wife, amounting to an all-pervading passion, and to his intense solicitude for the advancement of their son in the medical profession. He held all other interests subordinate to these.

The excellent woman to whom he was so devoted was not only his faithful consort, but she was the able sharer of all his studies. To her all his discoveries were first announced and the written results of his investigations first read. He always sought her clear judgment and approval of what he had written before he sent it to the printer. It is gratifying to know that he lived to bestow his care upon her until the end of her life, to commend her memory in the most impressive manner to their son, and to see the latter a leader in the chosen branch of his profession.

The estimates of Dr. Engelmann's personal character which are recorded in the preceding paragraphs are those of persons who

* Gray's, Torrey's, and Engelmann's peaks are near one another, all three having been named at the same time by Dr. Parry (see Am. Jour. Sci., vol. xxxiii, 2d ser., p. 235). The names of Torrey's and Engelmann's peaks are often omitted from maps, even when the name of Gray's peak is retained; also, through faulty pronunciation and spelling, the name of the cañon mentioned above appears upon certain maps and in other publications as "Ingleman's cañon."

knew him intimately and to whom his genial feelings were freely shown. I, who knew him less intimately, was impressed with the more conspicuous features of his character. It was evident to all that he was an eminently just man, always ready to accord to others their due, and that he held in abhorrence personal controversy and detraction. In his common intercourse with men, while free from all unkindliness of manner, he was always circumspect, often reticent, and always maintained the full dignity of superior manhood.

Noteworthy peculiarities of one's character are often revealed by his manner of speech. This was especially true of Dr. Engelmann. The language of his conversation and of his public addresses, like that of his writings, was clear and explicit. He affected no oratorical forms or verbal embellishments, but appealed directly to the intelligence of his auditors. He occasionally delivered lectures on scientific subjects when the interests of St. Louis or of its institutions could be thus promoted, but he never sought opportunities for public speaking, preferring to communicate his thoughts by the pen. His extemporary communications to the St. Louis Academy, however, were very numerous. These were usually short, always important, and always directly to the point under discussion, for life was too earnest and too full of labor for him to waste either time or words upon any occasion. While admiring his other qualities, I confess that I like to view his character in these more general aspects.

I cannot, however, refrain from adding my testimony to his geniality by relating the circumstances of my first interview with him, which occurred about twenty-five years before his death. I had built a skiff upon the upper Mississippi and was making a geological journey down the river. Arriving at St. Louis, I greatly desired to meet Dr. Engelmann, whose name was already well known to me, and, although I was weatherbeaten and without a suitable change of clothing, I ventured to call upon him at his office. I had framed excuses for myself, but immediately forgot them all in the cordial greeting he gave me. I needed no formal introduction. It was enough for him to know that I was a young naturalist seeking knowledge. Our interview was broken by a call for his professional services, but in the short time it lasted he said much, and his conversation was full of instruction to me. Beside this, his hearty German *Gemüthlichkeit* was so delightfully blended with the Westerner's freedom from conventional forms that the recollection of my interview has always brought me pleasure.

Dr. Engelmann's last resting place is in the beautiful grounds of Bellefontaine cemetery, in the northern suburb of St. Louis. It is situated in the central part of the cemetery, and is surrounded by small specimens of several of the Rocky Mountain conifers, the study of which was one of his chief pleasures. The grave is marked by a moderately heavy slab of bluish granitoid stone, the edges of which are gracefully moulded at the top and sides. The slab stands erect upon a plinth, and this in turn rests upon a basal block, all of the same kind of stone. The face of the slab bears the following inscriptions:

DORA,
WIFE OF
DR. GEORGE ENGELMANN,
BORN IN BACHARACH,
MAR. 10, 1804,
DIED IN ST. LOUIS,
JAN. 29, 1879.

GEO. ENGELMANN M. D.
FRANKFURT FEB. 2, 1809.
ST. LOUIS, FEB. 4, 1884.

In the preparation of biographical memoirs for the Academy it has become customary to append a list of the published writings of the deceased member. In this case, however, I do not think it necessary, because nearly all of Dr. Engelmann's publications were botanical, and all these have been republished in one large quarto volume, the title of which is given in a foot-note on a preceding page. With few or no exceptions, all his other published scientific writings and discussions are to be found in the three first volumes of the Transactions of the St. Louis Academy of Science. The large volume referred to gives full bibliographical references to the places of original publication of the parts of which it is composed. Besides this, a list of Dr. Engelmann's published works was prepared by Professor Sargent for Professor Coulter's Botanical Gazette, volume ix, pages 69 to 74, inclusive. This list was republished, with some additions, in "Der Deutsche Pionier" by Mr. H. A. Rattermann, in connection with his memoir of Dr. Engelmann already referred to.

MEMOIR

OF

CHARLES HENRY DAVIS.

1807-1877.

BY

C. H. DAVIS.

READ BEFORE THE NATIONAL ACADEMY, APRIL, 1896.

BIOGRAPHICAL MEMOIR OF CHARLES HENRY DAVIS.

CHARLES HENRY DAVIS was born in Boston, January 16, 1807. He was the youngest son of Daniel Davis, Solicitor General of the State of Massachusetts. Of the other sons, only one reached maturity, Frederick Hersey Davis, who died in Louisiana about 1840, without issue. The oldest daughter, Louisa, married William Minot, of Boston.

Daniel Davis was the youngest son of Hon. Daniel Davis, of Barnstable, justice of the Crown and judge of probate and common pleas for the county of Barnstable. The family had been settled in Barnstable since 1638. Daniel Davis, the second, studied law, settled first in Portland (then Falmouth), in the province of Maine, and moved to Boston in 1805. He married Lois Freeman, daughter of Captain Constant Freeman, also of Cape Cod. Her brother, Rev. James Freeman, was for forty years rector of the King's Chapel in Boston, and was the first Unitarian minister in Massachusetts. The ritual of King's Chapel was changed to conform to the modified views of the rector, and remains the same to this day. Another brother, Colonel Constant Freeman, served through the Revolutionary war and attained the rank of lieutenant colonel of artillery. In 1802 he was on the permanent establishment as lieutenant colonel of the First United States Artillery. After the war of 1812–'14 he resigned and was Fourth Auditor of the Treasury until his death, in 1824. Still another brother, Nehemiah Freeman, also served in the Army.

Charles Henry Davis was educated at the Boston Latin School and entered college (Harvard) in 1821. He left college in 1823 to enter the Navy, but subsequently took his degree, and his name stands on the Triennial Catalogue in the class of 1825. His first cruise in the Navy was to the Pacific, on board the frigate *United States*, with Commodore Isaac Hull. During this cruise he also served on board the schooner *Dolphin*, under Lieutenant Commanding John Percival. The *Dolphin* made an interesting voyage among the remote and at that time unknown islands of the south Pacific. She visited the Mulgrave islands of the Marshall group in search of the mutineers of the whale ship *Globe.* In this hazardous service Davis, with the first lieutenant, nearly lost his life through the treachery of the natives. The boats of the *Dolphin* had followed the native canoes across the lagoon, the group of islands being a coral atoll, in pursuit of parties among which it was believed the mutineers of the *Globe* were concealed. Finally the natives landed, and on the arrival of the boats approached the beach with gestures of friendship. The crews were invited to land and seat themselves on the ground at a feast which had been prepared; but, as was afterward discovered, each savage was armed with a heavy stone, which he concealed by sitting on it. At a preconcerted signal all the white men were to be knocked on the head. This simple ruse had already been tried effectively with the crew of the *Globe;* but two of the number were spared on account of their youth, and these were now among the natives and undistinguishable from them, but they gave the alarm, and Lieutenant Paulding averted a general massacre by seizing the chief and presenting a pistol to his head. The two survivors of the *Globe* were brought back to the United States. The *Dolphin* on this voyage discovered a new island of the Society group, which was named Hull island in honor of the commodore. She was also the first American man-of-war to visit the Sandwich islands. Lieutenant (afterward Rear Admiral) Paulding wrote a very interesting narrative of this voyage, called the "Cruise of the Dolphin." The book is now very rare.

Davis returned to the United States in the frigate *United States* in 1827. His next cruise was to the West Indies in 1828, in the sloop *Erie.* This cruise was a very short and uneventful one, except that the *Erie* on the passage out encountered a severe storm off Hatteras, which is noteworthy only from the fact that the ship sailed round the outer edge of a cyclone for four days. Of course nothing was known then among seamen of the laws of storms, and the manoeuver generally resorted to in the ships of that day in very heavy weather was to scud under bare poles. The log-book of the *Erie* shows that she kept before the wind, changing her course for every shift of wind and making extremely heavy weather of it, until as a last resort it was determined to bring the ship by the wind. As she happened to lie in the right-hand semicircle and was brought to on the starboard tack, the storm almost immediately ceased, an event which was doubtless attributed to the providence of God. Redfield, if he had not already published, must at least have begun his studies of the West India hurricanes, but the sailors of that day ignored the discovery. With them the wind blew as it listed, and no man knew whence it came or whither it went, and it is a rather remarkable fact that a school in which the instructors were of this character should have produced many officers of sterling scientific attainments, who have been, on the whole, the best that the Navy has ever shown, for in 1828 of instruction on board ships for the young gentlemen there was almost nothing. Some of the larger vessels carried professors of mathematics, but in ships like the *Dolphin* and *Erie* a youth learned by virtue of the impetus that was in him, or not at all.

When the *Dolphin* was at the Sandwich islands in 1825 the port of Honolulu had already become a resort of American whale-ships. An American ship was wrecked on one of the neighboring islands and the master applied to Captain Percival for assistance, as the natives had begun to plunder the wreck and there was treasure on board which he was unable to guard. The *Dolphin* was dismantled and refitting, but Captain Percival chartered a brig and proceeded to the scene of the wreck, manning the brig from the *Dolphin's* crew. He took Davis with him, and the cargo and treasure were saved. Upon the return to Honolulu the master of the wrecked ship declined to pay the charter of the brig, and Captain Percival adopted the summary process of deducting the amount from the treasure, which was still in his possession. This involved him in a serious dispute with the master, who succeeded in exciting against him the animosity of the missionaries, who virtually ruled the islands. It is unnecessary and would be uninteresting to enter into the details of this controversy, which is only worth noticing, as it affected indirectly Davis' subsequent career. Captain Percival had returned to the United States as first lieutenant of the *United States*, and the ship was no sooner paid off than he was arrested on a civil process by the owners of the ship whose cargo he had saved from plunder. Subsequently he was virulently assailed at the Navy Department by the society of missionaries with whose representatives he had quarreled in Honolulu, and in order to set the matter at rest he demanded a court of inquiry. This was ordered, and as Davis was an important witness he was detached from the *Erie* in the West Indies and sent home. The court was held in Boston, and so for the first time in nearly six years Davis was at home again. He asked and obtained a leave of absence in order to prepare for his examination, to which he was now entitled, and passed the winter of 1828–'29 at his father's house in Boston and in attendance before the board of examiners at the New York navy yard. The passed midshipman's warrant is dated March 23, 1829.

After passing, Davis was appointed acting sailing-master of the sloop *Ontario*, and made a three years' cruise in the Mediterranean. There is nothing specially noteworthy as to this cruise. The ship carried out a consul-general to Algiers, and also took the last of the tribute money paid by the United States to the Dey of Algiers. She was present at Algiers during the French operations in 1830. She wintered with the squadron at Port Mahon, then the permanent station for the United States ships, where the Government had storehouses. She performed some service in the Levant. It was principally on occount of the intimacies and associations formed during this cruise and the excellent school which the Mediterranean then afforded for the young naval officer that this period of service left a lasting impression on Davis' mind and character. Dahlgren was a midshipman on board the *Ontario*, and has left a spirited account of this his first cruise in his journals. Dupont was one of the lieutenants of the ship, and the intimacy formed between Davis and Dupont lasted through life and strengthened with time. McBlair, Davis' own classmate and shipmate on board the *United States* and *Dolphin*, was also on board. The friendship between these two was interrupted by the civil war and resumed in the last years in Washington. Commodore James Biddle commanded the squadron, and in a letter addressed to the Commodore by Captain Gordon, reporting on the qualifications of the officers of the *Ontario*, he says: "Lieutenant C. H. Davis is devoted to the improvement of his mind; his country may expect much from him." Habits of study were formed on this cruise, and a bent was given to his mind by the duties of his position as sailing-master. From the navigation of a ship to the higher pursuits of astronomy and hydrography is a natural step to the young man of scientific tastes.

The *Ontario* returned home in 1832, and, after a leave of absence, Davis was appointed to the sloop *Vincennes* as flag-lieutenant to Commodore Alexander Wadsworth. The *Vincennes* fitted out at Norfolk and sailed in 1833 for the Pacific, acting as flagship until the arrival on the station of the frigate *Brandywine*. This cruise was also a short one. The *Vincennes* passed a year on the west coast of South America, taking care of American interests in the interminable revolutions which form the whole history of the South American republics. She was for some time in the Guayaquil river during civil disturbances in the state of Equador. There was nothing but the most dreary monotony connected with this kind of service. While the *Vincennes* was at Callao, in the autumn of 1834, an American whale-ship was condemned by consular survey, and it became necessary for the Commodore to take charge of this vessel and send her to the United States. Davis asked for and obtained this duty. He therefore sailed from Callao in September, 1834, in command of the barque *Vermont*, with three midshipmen as subordinate officers, and made the passage round Cape Horn, reaching New York in February, 1835. The ensuing year he passed at home. His father had retired from active life and was now settled in Cambridge, which was Davis' home until the breaking out of the civil war. His father died in October, 1835. In 1836 he was connected with the Naval Rendezvous at Boston, recruiting for the Brazil station, and in 1837 he was appointed to the razee *Independence*, destined as flagship of that squadron. The *Independence* sailed early in that year, having on board the United States minister to Russia and his family. The ship touched first at Southampton, and the officers had an opportunity to travel somewhat in England. Davis was in London at the death of the king (William IV) and saw the young queen. From Southampton the *Independence* proceeded to Cronstadt, landed the minister, and the officers visited St. Petersburg and were presented at court. The Czar Nicholas also visited the ship. The ship went to Stockholm, and thence sailed for Brazil, touching at the Island of Madeira. The three years from 1837 to 1840 were passed on the coast of Brazil and in the River Plate. The *Independence* returned to the United States and was paid off in April, 1841.

This event closes what may be considered as the early period of Davis' naval career. He had now been seventeen years in the service and almost constantly at sea. He had visited many parts of the world at a time when travel meant much more than it does today. He had formed habits of observation and study, and was already regarded as an officer of experience and known as a man of parts. He had reached a stage in his professional life when, if not actively employed in labor of his own seeking, he would be doomed, by the system then in vogue, to an indefinite period of idleness and inactivity. Under these circumstances his mind naturally turned toward those pursuits which he had by study fitted himself to follow. The Coast Survey offered exactly the field suited to his talents. Under the superintendency of Hassler and Bache the Survey had made tremendous strides, and was recognized as the one great scientific institution under Government control. The whole Atlantic coast of the United States was then under preliminary examination, and the original surveys, which have ever since formed the basis of coast work, were then in progress. Besides this, there was much to be done in the examination of harbors and plans for harbor improvement. Davis gave himself up to this work with entire and characteristic energy. His connection with the Coast Survey began in April, 1842, though it is on record that he was an applicant for service on the Coast Survey on his return from the Mediterranean in 1832, and he continued in that service until July, 1849, almost without interruption.

During this period he served principally on the New England coasts in command of hydrographic parties, but he was also connected with several harbor commissions not only in New England but in the South. One of the first fruits of his work was the discovery of Davis' New South Shoal, 20 miles south of the Nantucket shoals. His harbor work led him to an examination of the laws governing the geological action of the tidal and other currents of the ocean, and he published several papers on this subject. His "Law of Deposit of the Flood Tide" is still an accepted authority.

The meridian of Greenwich had been adopted in the Coast Survey as the prime meridian, and also generally by American geographers, but our navigators and astronomers were still dependent on the British Nautical Almanac, a disadvantage which had long been apparent to Davis, and his Coast Survey work served to strengthen his conviction of the necessity of a national ephemeris. Perhaps no one achievement of his life, not even excepting his later naval service as admiral, entitles him to higher or more lasting fame than the foundation of the American Ephemeris and Nautical Almanac. He was placed in charge of this work in July, 1849, and by the wisdom of the Navy Department was left absolutely unfettered in its execution. The Almanac stands as a monument to his success more enduring than brass or marble. Of his methods of administration it is not necessary to speak. Those who assisted in the early development of the work have testified, and the Almanac itself bears witness.

The Almanac was established in Cambridge, for the facilities afforded by the University and the Cambridge Observatory. Cambridge had been Davis' home since 1835. In 1842 he had married Harriette Blake, youngest daughter of Hon. Elijah Hunt Mills, United States Senator from Massachusetts. In 1846 he built a house in a new street just opened, in close proximity to the college grounds, to the eastward of which the fields and meadows stretched in almost unbroken undulations to East Cambridge and the marshes. The years of residence in this house, though years of labor, were peaceful and happy ones.

Mrs. Agassiz, in the life of her illustrious husband, has drawn a picture of the society of Cambridge at this time. Perhaps it would be necessary to go back to the republics of antiquity to match the social life of the University town of this period in the highest intelligence combined with severe simplicity of living. It was a society peculiarly congenial to Davis. Agassiz himself was Davis' next-door neighbor. In the same street lived either collectively or successively Dr. Beck, Dr. Channing, Dr. Walker, Bond (whose house was temporarily fitted as an observatory, preliminary to the present establishment), Joseph Cook, Felton, Sparks (the historian), Jeffries Wyman, Dr. Peabody, Rev. F. D. Huntington, the family of Horatio Greenough, Henry Greenough, and Davis' own brother-in-law and bosom friend, Benjamin Peirce. Besides the latter, there were in Cambridge at that time names which have become conspicuous in astronomy and mathematics—some of them associated with the Nautical Almanac in its early days.

In 1853 Davis served with his friend Dupont as United States commissioner to the "Crystal Palace" Industrial Exhibition in New York. In June, 1854, after thirty-one years' service in the Navy, he was promoted in rank and received his commission as commander, and in 1856 the congenial Cambridge life and scientific pursuits were interruped by a call to active naval service. He was appointed to command the sloop-of-war *St. Marys* on the Pacific station. He sailed from New York in the autumn of 1856 in the frigate *Wabash*, carrying the relief officers and crew of the *St. Marys* to Aspinwall, and crossed the isthmus with his ship's company by the newly completed Panama railroad, and assumed command of his ship at Panama. For the next three years he cruised in the Pacific. He visited several of the ports on the west coast of South America, the Marquesas and Sandwich islands, and surveyed some uninhabited islands in the South Pacific, the principal object of these surveys being to determine the value of these islands as guano deposits. He spent several months refitting his ship at the newly established navy yard at Mare Island. Farragut was then in command at Mare Island, and Davis' letters at this period abound in allusions to his intercourse with Farragut and present an interesting summary of the character of this distinguished officer. It is worthy of remark, as an evidence of Davis' clearness of judgment, that in 1857 he estimates Farragut as possessing the qualities of a great naval commander.

In 1855 William Walker, a native of Tennessee and an American citizen, a born adventurer and a professional filibuster, had landed in Nicaragua with a handful of followers for the ostensible purpose of lending military assistance to the democratic party in the intestine troubles with which that republic was distracted. After a succession of adventures he became first generalissimo and then president and dictator of Nicaragua. Apparently secure in the possession of power, he began the distruction of his own fortunes by revoking the charter of the Vanderbilt Company, by which the transit through Lake Nicaragua was managed, and also by revoking the decree prohibiting slavery in the dominions of the republic, which had been in force for thirty-two years. Violent insurrections immediately broke out, which were seconded by other Central American republics, and to which the agents of the Vanderbilt Company rendered material aid. In the spring of 1857 Davis was sent to San Juan del Sur in the *St. Marys* to watch events in Nicaragua. By this time Walker was reduced to the last extremity and was besiged in Rivas, with constantly dwindling forces. His total destruction was now only a question of days. Acting entirely on his own responsibility, without instructions either from the Government at home or from the commodore on the station, and acting solely in the interest of humanity, Davis went to Rivas and by judicious pressure on the insurgent chiefs succeeded in raising the siege, and accepted the surrender of Walker with sixteen of his principal officers, carried them to Panama in the *St. Marys*, and sent them to the United States. His conduct of this affair was made the subject of a congressional investigation. It is needless to touch upon the political aspects of the Walker episode, which are sufficiently obvious. It is enough to say that Davis was justified; and, judged from this distance of time and from a standpoint afar from the violent political feeling of the day, it is difficult to see how he could have acted differently or how he could have been justified now had he remained at anchor in the *St. Marys* to witness quietly the massacre of American citizens, no matter how misguided. But the Walker episode had another result, as far as Davis was concerned, in bringing out conspicuously the leading traits of his professional character—fearlessness of responsibility, independence and soundness of judgment, and strong self-reliance. Though a trivial event in itself, it served to mark Davis as an officer who could be depended upon.

Davis was relieved from the command of the *St. Marys* in the spring of 1859, and returned to Cambridge and resumed his former place at the head of the Nautical Almanac. During his absence in the Pacific his English translation of Gauss' " Theoria Motus Corporum Coelestium " had been published, and he had had the honor of giving to the mathematical world the first English version of the Method of Least Squares, and he had beguiled the monotony of ship life on board the *St. Marys* by translating Kerhallet's " General Examination of the Pacific Ocean," with notes of his own. This book is still the standard authority for navigators of those seas.

When the civil war broke out, officers of mark in both services, regardless of rank, came directly to the front. Davis was only a commander in rank, and though the action of the retiring board of 1855 had advanced him rapidly in this grade he had held the commission only six years; but even had he so desired it would have been impossible for him to have continued in Cambridge after the war had once begun. He was summoned to Washington. His first duty there was as detail officer in the Navy Department, a duty which was onerous and distasteful to him, but which he was, nevertheless, exceedingly well qualified to perform. He was an excellent judge of men. As an administrator, he possessed the really great quality of recognizing the capacity of others and of leaving each to the performance of his special duties without interfering, looking only to general results, but at the same time the duties of detail were thankless and distasteful. He also served as a member of what was known as the "Construction Board," which had under consideration the plans of ships to be built and added to the Navy. The civil war came at a time when naval architecture, especially as applied to men-of-war, was just entering upon the transition stage, which has ended in the steel steamers of the present day, and the board had to consider new forms of construction and to face ideas which were novel to the seamen of the day. The three types of armored ships, or "iron-clads," as they were called in the language of the time, which the board finally adopted were represented by the *New Ironsides*, the *Galena*, and the *Monitor*. Of these three the first was the only one which was really efficient as a sea-going fighting ship and the last is the one that became famous. It is proper to say that Davis was opposed to the *Monitor* design from the first and held out against the other members of the board. As a scientific man he knew that the contrivance of Ericsson was a false design and worthless as a sea-going ship; he knew that the principles of naval architecture rest on laws of nature immutable as those which control the motions of the heavenly bodies, and that he who proclaims that he has "invented" a ship which shall defy these laws simply proclaims himself a charlatan. He yielded, but he did so because the *Monitor* was the one type that could be hastily constructed and because as a floating battery and in smooth water she might do some service; but it is told of him that when he had signed the report authorizing the construction of the *Monitor* he handed the model to Ericsson and said, "Mr. Ericsson, you can take that little thing home and worship it and it will be no sin, for it is not made in the likeness of anything in the heavens above or the earth beneath, or the waters under the earth." It is not necessary to defend his position with regard to the *Monitor*. He could not foresee the destiny of the vessel, neither could he foresee, though he might guess, that her ultimate fate would afford the clearest possible proof of the soundness of his judgment; but could he have foreseen the far-reaching effect of the pernicious fallacy to which the *Monitor* gave birth it is safe to say he would not have yielded. It has been said by many writers that at the beginning of the war people went mad. Some people did—wise men kept their heads—and the terror inspired at the North by the building of the *Merrimac* and by the destruction of the wooden frigates at Hampton Roads was very nearly akin to madness. The *Monitor* arrived in the nick of time, fought a drawn battle, and although she neither captured nor destroyed her antagonist she crippled her, and the northern seaports breathed freely again. The real condition of the *Merrimac*, or her capacity for mischief, were neither known nor questioned. She was a monster to be dreaded, a new thing which some one had "invented" which was to reverse all preconceived notions of warfare; and another, a man of superior genius, had in the very nick of time "invented" something even more novel and ingenious by which her destruction was accomplished; and so the *Monitor* left her lesson and sank miserably at the end of a tow-line. Writing in 1799 of the French possession of Louisiana and Florida, Washington had said: "No less difficult is it to make them (the people) believe that offensive operations oftentimes are the surest, if not the only, means of defense." This lesson never has been learned. If it could have been inculcated as applied to naval defense by the experiences of the civil war, the false lesson taught by the *Monitor* has belied it, for this has taught the Navy that the part of American seamen in defensive warfare is to skulk in harbors and shoal waters in vessels that cannot keep the seas, and it has taught the people at large that a sea-going fleet forms no part of an effective scheme of defense, and that at a pinch something can always be "invented" to baffle an enemy, no matter how powerful.

But in the mean time other services were in sight more congenial than bureau work in Washington. For the success of naval operations on the southern Atlantic coast it was necessary that the Government should hold a harbor sufficient for the accommodation of the largest ships, where stores could be accumulated and repairs effected—in short, a base nearer the scene of operations than any northern port. After consultations, in which Davis took part, in Washington, the expedition against Port Royal was planned. The command was given to Dupont, and Davis was named as fleet captain and chief of staff. A fleet of more than fifty ships-of-war and transports assembled at Hampton roads, and sailed on the 29th of October, 1861. Off Hatteras the fleet encountered a heavy gale, in which the smaller vessels and transports suffered severely, and the fleet was dispersed, so that on the fourth day out but one ship of the great fleet was visible from the deck of the flagship *Wabash;* but Port Royal bar had been given as the rendezvous in case of parting company, and the frigate kept on. She was joined by most of the men-of-war before arriving at her destination, and the transports joined soon after. On the morning of November 4 the *Wabash*, with twenty-five ships in company, anchored outside the bar at Port Royal. The importance of Port Royal had been recognized by the Confederates, and the channel was defended by strong works on Bay point and Hilton head, and all buoys and aids to navigation had been removed. To replace these, so that the heavy ships could cross the bar in safety, was the first care, and this duty was performed by Davis and Mr. Boutelle, of the Coast Survey, and before dark they had sounded out and buoyed the channel, and the next morning the heavy ships were piloted into deep water inside the bar and a reconnaissance made in force to draw the fire of the forts. Early on the morning of the 9th the signal was thrown out by the flagship for the fleet to get underway and form line-of-battle.

The Battle of Port Royal Bay has been somewhat overshadowed by the later naval victories of the war, but at the same time it was admirably planned and brilliantly executed. It was a battle in which ships engaged and captured forts on shore which were supposed to be impregnable to attack from the sea, for the army remained on board its transports and took no hand in the fighting, not landing until the forts had been abandoned under the fire of the naval guns. It had a good moral effect, for it came at a time when the Confederate arms had been generally successful and the feeling of despondency at the North was widespread, and this effect was felt abroad as well as at home. The object for which the expedition set out had been perfectly successful, and the plan carried out in its entirety, without hitch or mistake.

Davis remained as fleet captain with Dupont until the spring of 1862. His work was principally staff duty and organization, but in January, 1862, he commanded an expedition into Warsaw sound, with the object of cutting communication between Fort Pulaski and Savannah. He left Port Royal with seven ships and three transports, having on board 2,400 men. The vessels entered Little Tybee river and passed Fort Pulaski, but were brought to a stop by heavy piles driven in a double row across the channel above Wilmington island. Here they were attacked from above by the fleet of Commodore Tatnall and fought an action lasting only half an hour, in which the Confederate squadron was driven back. As a demonstration, this expedition may be considered a success, although it was not fruitful of results.

Flag Officer A. H. Foote, who had been in command of the Mississippi flotilla from the beginning and had distinguished himself in several engagements with the enemy, had been severely wounded at Fort Donelson and had suffered almost continually from his wound for three months. During the month of April his fleet had been before Fort Pillow, though without carrying on any active operations. His health now gave way, and it became necessary to relieve him of the command, and Davis was named as his successor. Foote and Davis were old friends. Though not of the same date, they had been shipmates on board the *United States* as midshipmen in 1826, and they had served together in the West India squadron in 1828. It was arranged that Davis should go to the Mississippi, nominally as second in command, but this was done to spare as much as possible Foote's feelings. Foote never had anything to do with the squadron after Davis succeeded him, and he was relieved before Fort Pillow on May 9, 1862. Davis hoisted his flag as flag officer on board the iron-clad *Benton*. The new flag officer, who was entirely strange to river work, had very little time for reflection, for on the very next day, at an early hour in the morning, the Confederate flotilla, consisting of eight armored vessels, came out from under the guns of Fort Pillow and attacked the Union squadron. Davis had seven iron-clads to the enemy's eight. A severe engagement followed, the enemy fighting with great spirit and using their vessels as rams, by which two of Davis' ships were sunk. These were subsequently raised and repaired; but the Union ordnance was far superior to that of the enemy and their practice better, and the machinery of four of the enemy's vessels was disabled. At the end of an hour's hard fighting the enemy succeeded in withdrawing under the guns of the fort.

The flag officer now commenced a vigorous bombardment of Fort Pillow, which lasted almost without intermission until the 4th of June, the enemy replying with a constant and well directed fire; but here, too, the superiority of the Union gunnery became apparent. On the night of June 4 a number of explosions were heard in the fort, which led the flag officer to believe that the garrison was about to evacuate the place. He therefore gave the order to get underway at 4 o'clock on the morning of the 5th. At daylight the fort was found to have been evacuated during the night. Davis now dropped down the river and at dark was anchored within two miles of the city of Memphis. His squadron was reduced to five iron-clads, for the two which had been sunk in the action off Fort Pillow had not yet rejoined, but he was reinforced by a new element in the form of a flotilla of four rams, commanded by Colonel Ellet, a most dashing and gallant officer, who, though he acted with the army and was not placed under the flag officer's orders, coöperated in complete harmony with him and contributed largely toward the complete victory of the following day, although only two of his rams were engaged. These rams were ordinary river steamers, protected as well as possible, and strengthened by longitudinal beams of wood. They carried no guns.

At twenty minutes past four on the morning of June 6, 1862, the Union flotilla was underway and stood down the river toward the city of Memphis. The Confederate fleet was discovered at the levee, and these immediately cast off and stood out to attack. They were the same eight ships which Davis had engaged a month before in front of Fort Pillow, and they opened the battle with a furious cannonade, to which at first it was difficult for Davis to reply without firing into the city and the hundreds of spectators who had gathered on the levee to witness the destruction of the Union flotilla; but the gallant Ellet dashed to the front with two of his rams, and the action immediately became close and general, terminating in a running fight between the iron-clads, which carried them 10 miles downstream. The result of the action was the total annihilation of the Confederate fleet. Of the eight ships that went into battle three were totally destroyod, four were captured and later were added to the Union fleet, and one escaped. In addition to this, five large transports and a considerable amount of cotton were captured, and a large ram and two tugs on the stocks at Memphis were destroyed. The loss of life on the Confederate side is not accurately known, but the estimate of killed and wounded is one hundred. On the Union side not a single vessel was lost, but the casualties included the gallant Ellet, who received a wound from the effects of which he afterwards died.

At 11 o'clock Flag Officer Davis received the surrender of the city of Memphis, and two regiments which had accompanied the fleet in transports marched in and took possession.

The squadron remained in front of Memphis for about three weeks, but on June 12 an expedition of four ships was sent up the White river to destroy certain batteries, clear the river of the enemy's vessels or boats, and open communication with Major General S. R. Curtis, who after the battle of Pea Ridge had commenced a march eastward to the Mississippi. The ships attacked and captured the batteries on the 16th, and this action would have been insignificant but for the fact that a shell from the batteries, entering the casemate of the *Mound City*, exploded in the steam drum. Many of the crew were killed outright or frightfully scalded, and many jumped overboard and were drowned. Out of 175 people on board only 35 escaped uninjured. General Curtis did not arrive in time to communicate with the squadron, but reached the Mississippi at Helena, about 80 miles below Memphis.

Of the battle of Memphis, Admiral Porter says: "For the second time Rear Admiral Davis won a strictly naval victory, and won it without a single mistake. * * * In his report he makes no distinction among his officers. He simply says, 'The officers and men of the flotilla performed their duty.' The proof of the manner in which it was performed was the total annihilation of the enemy's forces. Take the battle with its results, it was one of the handsomest achievements of the war; but it did not receive that general notice which it deserved." Davis himself in after life seldom referred to this battle. To boast or vociferously to claim recognition for himself on account of services which he had performed was as foreign to his nature as it was to talk in German, though he understood both languages.

On June 29 Davis left Memphis with his fleet and six mortar-boats in tow of transports. and on July 1 anchored at Young's Point, a few miles above Vicksburg, and there joined hands with Admiral Farragut's fleet from New Orleans. The entire Mississippi from Cairo to the Gulf had now been navigated by Union vessels; but another year was to elapse before the stronghold of Vicksburg should fall. At this time Farragut was making his first attempt against Vicksburg. Some of his vessels were above and some below the fort, and the combined fleets of Farragut and Davis remained in this position during the month of July. On the 15th some of Davis' light-draft vessels were sent up the Yazoo river on a reconnaissance to obtain information with regard to the large iron-clad ram *Arkansas* which was known to be building and about which the most extraordinary reports were in circulation. They had not been gone long before firing was heard, and they soon appeared at the mouth of the Yazoo, coming down at full speed and closely followed by the *Arkansas*.

It so happened that not one of Farragut's fleet had steam up and the *Arkansas* passed directly through it, receiving no injury from the broadsides of the ships. and got into shelter under the guns at Vicksburg. Farragut undertook to destroy her by passing the batteries at night, but the attempt failed, and it soon became apparent that the Navy alone could effect nothing against the strong fortifications of the place, so on the 27th Farragut returned to New Orleans and Davis' fleet went up the river again.

During the remainder of Davis' period of command on the Mississippi no operations of any consequence took place. The river above Vicksburg had been cleared of the enemy and only Vicksburg remained, which was to defy the combined operations of the Army and fleet for another year.

The summer had been a very trying one to Davis. In the torrid and malarial climate of the river his health had suffered. The month of August had been passed principally in establishing the naval station and depot at Cairo. He had intended to occupy the Yazoo river and thence to carry on operations against the enemy; but he found that nothing could be done in that stream at low water, and the enemy had erected heavy barricades, defended by batteries, at Haines' bluff, some miles above the mouth of the Yazoo, and with these his force was not sufficient to contend, and in fact his field of operations was entirely too wide for the force under his command. His ships all needed repairs, and he went to Cairo for this purpose. Here his health broke down completely. He suffered from repeated attacks of chills and fever, and in October he was relieved by Admiral Porter.

Davis had been promoted to the rank of post captain, then the highest grade in the Navy, in 1861. By virtue of the command of the Mississippi flotilla he became flag officer, and was made commodore on the creation of that grade in July, 1862. He became a rear admiral on February 7, 1863, and on the same day the President signed a vote of thanks of Congress passed for the victories of Fort Pillow and Memphis. This vote of thanks was not an empty honor, for it carried with it certain privileges, and up to this time it had only been conferred on such officers as had commanded in chief in battle. The list of rear admirals at this time was Farragut, Goldsborough, Dupont, Foote, Davis, and Dahlgren, in the order named. Each one had been promoted for cause.

About this time an act passed incorporating the National Academy of Sciences. Of this the Admiral wrote: "Congress has incorporated a National Academy of Sciences, with fifty incorporators, of which I am one. This measure, from which should proceed a great institution, is due solely to Mr. Wilson, Senator of Massachusetts."

In 1863 Admiral Davis established the Bureau of Navigation of the Navy Department by becoming its first chief. His original conception of this bureau was to unite under one head all scientific work pertaining to the Navy as related to astronomy, hydrography, and navigation. The scheme included the Naval Observatory, the Hydrographic Office (though this was not established as an independent branch until 1866), the Nautical Almanac, the Compass Office, then becoming a most important branch, owing to the introduction of iron ships, and all matters pertaining to the purchase and care of nautical and astronomical books and instruments and of such articles of a ship's outfit as belong properly to the master's department. Very much against the Admiral's desire, and although entirely foreign to his original scheme, the Office of Detail was incorporated with this bureau, although under a separate detail officer. Passing through successive stages of transmutation, this office has now absorbed the entire bureau, its scientific character is lost, and its title has become a misnomer. Admiral Davis remained in the bureau two years, and during his administration he began a book which should in some measure correspond to the "Admiralty Manual of Scientific Inquiry" and serve as a general guide to naval officers in scientific investigation abroad. Articles were prepared on various subjects by eminent scientific men, but the Admiral left the bureau before the book could be issued and his successor suppressed it.

Admiral Davis gladly relinquished the Bureau of Navigation in the spring of 1865 in order to assume a post which had long been the goal of his ambition, the superintendency of the Naval Observatory, to which he succeeded on the death of Gillis. Though this place had been made by his own act subordinate to the one he had quitted, it was in the line of duty entirely congenial to him and for which he was preëminently qualified. He served twice as superintendent of the Observatory, and whatever the intrinsic merits of his administration may have been, the fact remains that the Observatory reached its highest point of prosperity and efficiency under his direction. So well established was its reputation abroad and so efficient was its organization considered that the French copied our system and placed their national observatory under the administration of a naval officer of eminent scientific attainments, citing the success of the American system as their incentive. In 1866, and in accordance with a resolution of the Senate, Admiral Davis prepared, as a public document, a complete review of all surveys hitherto made with a view to possible routes for interoceanic railways and canals across the American isthmus. This book is still the standard authority on the subject, and was among the volumes used only last year (1895) by the United States Nicaragua Canal Commission. In this year also (1866) he served with Admirals Farragut, Dahlgren, and Porter on the board of admirals to review the services of naval officers during the civil war and to recommend promotions as a reward of merit. The labors of this board were an invidious and thankless task. Reward for gallant acts performed in war should be conferred on the spot and at the time or not at all. The obligations of this board assigned to it attributes that were nearly akin to the divine, and its results bore inevitable fruit for years in jealousy, heart-burning, and bitterness. But Admiral Davis was still a flag officer in activity, and after two years at the Observatory he was again called afloat and assigned to the command of the Brazil squadron. He fitted out in his flagship, the *Guerrière*, a splendid new steam frigate, at Boston, and sailed from that port in June, 1867, relieving Rear Admiral Godon at Rio de Janeiro after a passage of about thirty days.

Francisco Solano Lopez was the third in regular succession of the absolute dictators or tyrants who had ruled the so-called Republic of Paraguay since its foundation as an independent state. When Paraguay declared her independence of Spain in 1819, her remoteness from the sea and the occupation of all available Spanish forces in the attempt to quell simultaneous insurrections in the more accessible colonies caused her act to be ignored by the mother country. Paraguay became independent without a struggle or the effusion of blood. A congress held in Asuncion the same year named the celebrated Dr. Francia dictator for one year, and at the end of this period his nomination was confirmed for life. Very little is known of the actual condition of Paraguay in the reign of Dr. Francia, because he pursued a policy of complete seclusion and excluded all foreigners from the country. Stories were circulated imputing to him the utmost severity and cruelty, and he has generally been viewed as a gloomy and malignant despot. But the evidence rests principally on the testimony of two Scotchmen named Robertson, brothers, who had settled in Paraguay before the revolution and sought to open a commerce with England. These had offended the dictator and either fled the country or were banished. Carlisle has celebrated Dr. Francia in a famous essay. For years the country remained as isolated to the outside world as the heart of Thibet. On the death of Francia, in 1840, a short period of anarchy followed, which was succeeded by another dictator in the person of Don Carlos Antonio Lopez. He followed very much the same course as Francia, except that he was more liberal to foreigners. A tax was, however, levied on all vessels navigating the Paraguay river. Lopez took the title of president and established a constitution by the terms of which the congress could only be convened by an act of the president; the president, in case of death or disability, was to be succeeded by the vice-president, and had the power of nominating and appointing the latter; so that Lopez had only to name his own son vice-president to make the succession secure in his own family. In 1855 the United States steamer *Waterwitch*, while surveying in the Paraguay river, had been fired into from a Paraguayan battery and one man killed. The United States therefore sent a naval expedition, with a commissioner, to demand and enforce reparation. In 1859 the commissioner of the United States concluded a treaty with Paraguay, and from that time a United States minister had continued to reside at Asuncion. Francisco Solano Lopez was educated in France, and being secure in the succession to the rulership of his country he received a military education and imbibed rather ambitious ideas in the France of the second empire. He succeeded his father, Carlos Antonio, in 1862. He was even more liberal than the latter, and virtually opened the country to commerce, but maintained the tax on vessels navigating the Paraguay. This tax was a sore point with Brazil. The Paraguay river was the highway to her southwestern provinces and its free navigation an important question. Moreover, Lopez had become aggressive. He had Napoleonic ideas of conquest and military dominion. A conflict between the two countries was inevitable. War broke out in 1864 and dragged on for six years, the Paraguayans fighting against overwhelming odds, with great spirit, the allies, for Brazil had formed an alliance with the Argentine Republic and Uraguay, having the advantage in vastly superior numbers. The Paraguayans were driven up the river from one stronghold to another, the fighting taking place almost exclusively along the river course, and Paraguay remaining as hermetically sealed to the outside world by the operations of the war as it had been in Francia's time, for the river is the only approach to the country. Meanwhile the American minister continued to reside at Asuncion long after every other foreign representative, consular and diplomatic, had withdrawn.

Such was the condition of affairs in the River Plate when Admiral Davis took command on the station. To keep open communication with the minister at Asuncion was one of the duties which devolved on him.

The war on the part of the allies degenerated into a personal war against Lopez, who was denounced as a tyrant and miscreant whom it had become a virtue to destroy. Stories of his barbarity were rife in Rio de Janeiro and Buenos Ayres, and these stories may have been true or not, but outside of Paraguay only one side of the case has ever been heard, for Lopez had no friends beyond the confines of his own dominions. The country was a military camp. Every male capable of bearing arms was enrolled and most of the females were with the army, so that the towns and villages were deserted, industry, except as related to military affairs, was suspended, and the dictator was commander-in-chief. Even had he been the constitutional president of a free country the situation would have been the same, for the whole country was in a state of siege and perforce under martial law, and martial law is apt to be rigorous law in all countries. The American minister had written to the State Department in the early part of the war in terms of the most fulsome flattery of Lopez, but unfortunately the minister himself was beginning to get into trouble with both sides. He was accused by both parties to the war of using his diplomatic privileges to further his private interests. These stories may or may not have been true, but in this case at least both sides were heard. The Brazilians accused him of carrying on a profitable traffic in supplies and arms which were passed unexamined through the Brazilian blockading fleet as the personal property of the American minister and sold to the Paraguayans at a considerable profit, and the Paraguayans accused him of acting as a spy in the interests of Brazil and selling military information to their enemies, and later Lopez accused him of aiding and abetting a conspiracy which he discovered, or pretended to discover, against his life and of harboring the conspirators and refugees from military justice in the legation of the United States. Be this as it may, a simple recital of these circumstances is necessary in order to make clear a situation of affairs in which Admiral Davis now became involved and with which it became necessary for him to deal in his own way, and for the same reason a somewhat extended account of the actual condition of the republic of Paraguay and the circumstances attending the war of extermination waged by the triple alliance against Lopez has been given, even at the risk of irrelevancy.

In the summer (or winter of the southern hemisphere) of 1868 the *Wasp* had been sent by the Admiral to Asuncion to communicate with the minister. The latter sent by this vessel a message to the Admiral, asking for the immediate return of the *Wasp*, as he felt his situation precarious and he might be obliged to leave at short notice; he wanted a vessel of war to fall back upon. So upon the return of the *Wasp* to Montevideo the Admiral despatched her again at once to Asuncion and gave her commander instructions to place his vessel at the minister's disposal.

The *Wasp* was an iron paddle-wheel steamer which had been captured on the blockade and taken into the service. She carried a light battery of brass guns, and was well adapted for river service. Her captain was Commander (now Rear Admiral) William A. Kirkland, who was admirably qualified for service in the River Plate, as he had passed almost his entire active service abroad in that country, spoke Spanish and the dialects of the river like a native, and was thoroughly familiar with the habits and traits of the natives, understood the native character, and was a skillful diplomatist as well as a gallant officer. Indeed, so well was the value of his qualities understood in Washington that he had been kept almost continuously on duty in the River Plate. He knew Lopez probably better than any one in South America.

When the *Wasp* reached Asuncion the minister was, or thought he was, living in daily terror of his life. The legation was surrounded by Lopez' police, and no occupant of it except the minister himself dared stir abroad. No overt act had been committed, though it was undoubtedly the intention of Lopez to immediately arrest any member of the household, except the minister himself, who ventured to quit the precincts of the legation. Captain Kirkland believed that the minister's fears were greatly exaggerated, but there is no doubt that he was thoroughly frightened, perhaps for causes best known to himself, and had but one wish, which was to get on board the *Wasp* and out of Lopez' reach at the earliest possible moment. Arrangements were therefore made for the immediate embarkation of himself and his household. The party left the legation headed by the minister himself, carrying the American flag, and no sooner were they on the street than two of the party, refugees whom the minister had sheltered, were forcibly arrested. Even then it is probable that had the minister resisted and protested the arrest would not have taken place, but on the first appearance of the police he had turned and fled. In dire precipitation he reached the boat which was in waiting for him and was conveyed to the *Wasp*. No sooner was he on board than he insisted on sailing at once. It was in vain that Captain Kirkland represented that, having undertaken to extend his protection to these men, it was shameful to leave without them, and that a demand from himself would procure their instant delivery. A frightened man does not listen to reason, and Captain Kirkland, against his own judgment, but acting in strict conformity with his orders, weighed anchor and proceeded down the river.

When the *Wasp* arrived at Buenos Ayres the Admiral was at Rio de Janeiro. There were no telegraphs in those days, but the news of this outrage upon an American diplomatist reached him in due course of post perhaps three weeks after the event. Admiral Davis never had the slightest doubt as to the course which it was proper to pursue in this case. He never probably gave the question more than one thought. In the bitter attacks upon him which followed his enemies charged him with vacillation, hesitancy, irresolution, reluctance to perform his obvious duty. This charge was absolutely false. Even if there could have been more than one side to the question, there could be no doubt to those who knew him as to the falsehood of such a charge, for it ascribed to him qualities which were foreign to his nature. The business which had brought the Admiral to Rio de Janeiro at this time was directly connected with this affair, or rather with Paraguay. He had received information from Washington that the new minister to Paraguay would arrive in the mail steamer now due in a few days. The former minister was recalled. While his ships were assembling at Montevideo he remained in his flagship to receive the new minister and offer him a passage to the river, and at the same time he knew that it was important to see the new minister and place him in possession of information relating to existing affairs. Matters would not be hastened by his presence in Montevideo at this time, for he had given the necessary orders for the assembling of the squadron and immediate preparations for the demonstration which he intended to make. In the meantime he was compelled to face a quarrel with the United States minister to Brazil.

On the arrival of the first news of the outrage at Asuncion this official's manner became so dictatorial, overbearing, and meddlesome that it was justly regarded by the Admiral as offensive and so resented. Admiral Davis never sought a quarrel in his life; but this was a case in which, to use his own expression, he must "fight to keep the peace." The new minister to Paraguay arrived and was received on board the *Guerrière*, which sailed at once for Montevideo. He was a distinguished officer of the civil war, and acted throughout this whole affair in thorough accord with the Admiral. Upon arriving at Montevideo the squadron was found assembled and preparations in active progress, and as soon as these could be completed, as many of the ships as could be floated over the bar at Martin Gracia proceeded up the river. These were the *Pawnee*, *Kansas*, *Huron*, *Quinnebaug*, *Shamokin*, and *Wasp*. The Admiral hoisted his flag on board the latter vessel.

It is about a week's navigation from Buenos Ayres to Asuncion, for after ships enter the narrower reaches of the Parana and Paraguay they must anchor at night, and the strong current of the river retards progress by day. It was in the midsummer (December) of 1868, and in the upper rivers the climate at that season is something infernal. All along the right bank stretches for miles the Gran Chaco, a noisome wilderness of jungle and morass, which no human being can enter and live and in which no living thing except alligators can dwell. A Brazilian army which entered this swamp for a march of about twenty miles to flank Asuncion died there like rotten sheep. From this bank great segments of tangled forest growth break away with the force of the stream and float down with the current in the form of floating islands, some of them of enormous extent, so that at times the river ahead seems to be land. These gather across the ships' bows and chains at night and must be cleared away with great labor in the morning. All the day a vertical sun beats down on the mirror of the river. In the furnace heat and damp of the swamps swarms of noxious insects breed, and these and the foul miasmas of the Chaco make the nights unbearable, and as a variety to these torments a tornado will occasionally sweep across the river from the south, and the temperature will fall forty or fifty degrees in an instant. The health of the squadron necessarily suffered. Many men were on the sick list from mosquito bites, and one man on board the *Wasp*, driven mad by these pests, jumped overboard and was drowned. The Admiral himself suffered, and though not actually ill he was wretchedly pulled down.

In the meantime Asuncion had fallen and was occupied by the allies. Lopez' last stronghold on the river was at a point called Angostura, about twenty miles below Asuncion, where he had erected a battery which commanded a bend of the river. When the *Wasp* arrived the Brazilian iron-clads were bombarding this battery, coming up into action in the morning and dropping down out of range at night. To those officers who had taken the hard knocks of the civil war at home the Brazilian methods of warfare seemed simply puerile. The Admiral had in his squadron guns enough to have knocked this battery down in half an hour if American methods had to be resorted to; but he had left the whole squadron some miles below the lower Brazilian lines, and came on alone with the *Wasp*, as he did not choose to make a show of force until it became necessary to use it. The new minister to Paraguay was also on board the *Wasp*, but it is needless to say that Lopez was unaware of this fact until the affair was concluded, nor was he aware, as he had no means of obtaining information from below, that the Admiral had a force back of him. On the morning after the arrival of the *Wasp*, which had anchored just below the battery and out of the line of fire, the Brazilian fleet came up into action, the leading ship carrying the American flag at the fore, a proceeding which called forth a peremptory challenge from Admiral Davis, as while this flag flew the fort did not fire, and the ships were enabled to get into position before the guns of the enemy could open upon them. It is needless to say that this experiment was not repeated. It was explained by the Brazilian admiral that this was intended as a signal to the *Wasp* to get out of the way. The *Wasp* was quite capable of taking care of herself; but this incident, trivial as it was, was perverted by the Admiral's enemies in their subsequent attacks on him.

Immediately upon his arrival in front of Angostura the Admiral had notified the commanding officer that he wished to communicate with the president. Lopez was with the army some miles in the interior, but a meeting place was arranged at an intermediate point. The Admiral sent his fleet captain and Captain Kirkland. The conference, so far as these were concerned, was limited to a peremptory demand for the immediate surrender of the two persons arrested from the protection of the American minister. Lopez would not have been a South American potentate if he could have yielded this point without talk. The men were actually at a place some distance in the interior, and it took a day to produce them, but they were delivered on board the *Wasp* as soon as they could be brought down. With them Lopez sent certain documents relating to the charges on which they had been arrested. These the Admiral could hardly decline to receive, as they were addressed to the Government of the United States. This closed the incident. The American minister then landed and presented his credentials, and the *Wasp* proceeded down the river, and within a week the whole squadron, with the exception of the one ship which had grounded with a falling river and was not floated until the following season, was in Montevideo again. Before the Admiral reached the United States Lopez was dead, his government overthrown, and Paraguay a Brazilian conquest.

This, in explicit terms, is the whole story of an event which if it had not borne fruit in bitterness and mortification and ended an honorable service of forty-five years in disgust, might have been dismissed in a single paragraph. It was the last incident of Admiral Davis' active career, and it is his own side of the case, which has never yet been given. His enemies placed their slander in the chronicles of the nation. It is difficult to explain the animus which dictated the attack on Admiral Davis which followed his conduct of this affair. It might be implied or inferred, but it is better to let the Admiral's story stand as a plain statement of facts. There was enough imputation on the other side. The parties in the attack were the minister to Brazil and the ex-minister to Paraguay. The former acted in retaliation for the Admiral's curt and proper reproof for his meddlesome impertinence and domineering conduct. The latter had no cause of offense and no complaint to make until the two had met and conferred. They both entirely mistook the Admiral's character. That he was a gallant and distinguished officer, a learned man, and a modest gentleman was a sufficient cause of offense, but they could not understand that force of character was not inseparable from brutality of deportment. Indeed, the fact that the Admiral was a cultivated man was publicly cited against him. To these two were added the two refugees whom the Admiral had rescued from what they and their friends believed to be impending death. These had been loud in their expressions of gratitude when first delivered, but they became the tools and instruments of the persecution. There was one other. An officer of the *Guerrière* had lent himself to this plot, and served as a spy and a talebearer against the Admiral. This person's name, if remembered at all in the service, is only remembered with infamy.

Admiral Davis returned to the United States in the *Guerrière* in June, 1869, in time to face a congressional investigation set on foot by his enemies. It was not enough that his conduct had been approved by the Secretary of the Navy and the President; the times were against him, for they were the same in which the name of a great and single-hearted warrior could be made the emblem of a shameless system of political knavery. One of the principals in this persecution was the member of a powerful political family, and though a person of less than no consequence himself, he had friends who commanded great influence and his interest was enough to control the investigation. A committee composed of members, every one of whom had prejudged the case and every one of whom was hostile to Admiral Davis, carried on the investigation. It failed to examine witnesses who could have testified in the Admiral's favor, and such evidence as was favorable to him was suppressed in the printed report of the proceedings of this committee; and in addition to the report of the committee a history of Paraguay, written and published by the ex-minister, rehearsed the whole complaint; but even this committee could not bring in a direct vote of censure. The charges against Admiral Davis were dilatoriness in proceeding to act after the first receipt of the news of the outrage in Paraguay; treating with Lopez and accepting the surrender of the two refugees under conditions, and receiving them and holding them as prisoners. These charges were all false. The first was inspired by the minister to Brazil, based on the quarrel in Rio de Janeiro; the second was founded on the fact that the men were not produced at once (they could not be), and because Lopez talked and sent certain papers on board which the Admiral could hardly refuse to receive; and the third charge was that the Admiral had refused to allow these men to communicate with the allied commanders while he was within their lines. They were exceedingly anxious to do so in order to convey military information by which they hoped to injure the Paraguayan cause. They were both men of doubtful character. One was an American adventurer and the other a British subject. They had both been in Lopez' service and were accused by him of conspiring against his life. They took refuge in the United States legation, and the minister, in order to give color to their presence, conferred on them some sort of nominal appointment as attachés, which, considering their situation as refugees, was clearly an injudicious thing to do. Admiral Davis had never credited the stories of Lopez' barbarity. He had the most reliable information of the actual condition of Paraguay during the war from Captain Kirkland, who made repeated trips up the river in the *Wasp*, and he had better evidence to judge by than any one in South America. Moreover, he was a man of sound mind and clear judgment, and he did not form opinions from gossip. Notwithstanding the dismal predictions that the men would be murdered, Admiral Davis was quite sure that he would find them in good health. The event proved that he was right. They pretended that they had been tortured by a process which they described to the committee and which must have left indelible physical traces, but their persons when received on board bore not the slightest evidence of violence. They were not even emaciated, though there was a decided scarcity of provisions in Paraguay, and some of the native soldiers were mere skeletons; but there is no doubt that they were thoroughly frightened and very vindictive toward Lopez.

Lastly, the facts that the Admiral had actually accomplished the object of his undertaking, which had been carried out with spirit and firmness, and that his proceedings had the approval of the President and the Secretary of the Navy were set aside and ignored. In its findings the committee virtually censured him because he was a gentleman and not a blackguard. The matter never came to a vote in the House.

But the Admiral at this time had other causes of preoccupation more agreeable to him than the proceedings of this committee. Upon his return to the United States in June, 1869, he had gone with his family to the hills of Maine for the summer. In the autumn he took duty in Washington as a member of the Light-House Board. During his absence in Brazil the University of Harvard conferred upon him the degree of doctor of laws, the only instance in the history of the institution in which that honor has been paid to a naval commander.

In 1870 Admiral Davis was appointed to command the naval station at Norfolk and spent three years at this post. They were uneventful years and to himself and his family a period of social isolation. Southern society had not yet recovered from the effects of the war; the Admiral's former Norfolk friends and old brother officers were still in the sulks; but the time passed not unprofitably, for the Admiral was a man to whom leisure was not idleness. The official duties of his station were not onerous, and with his books and the society of his family the time was not lost. He returned to the Superintendency of the Observatory early in 1874, in time to take part as chairman of the Transit of Venus Commission in the preparations for the observations of that year.

The journals and memoranda of the voyage of the Arctic discovery ship *Polaris*, together with Captain Hall's journals of previous expeditions to the Arctic regions, had been purchased by the Government, and in accordance with a resolution of the Senate were entrusted to Admiral Davis to edit. The Admiral worked industriously on these, assisted by Professor Joseph Nourse, who published the second narrative after the death of the Admiral. This work and labor in connection with the Observatory and naval exhibit at the Centennial Exposition occupied the last year of his life. The summer of 1876 in Washington was an extremely hot and unhealthy one, but the Admiral worked faithfully on the *Polaris* narrative, although he had been obliged to abandon the Observatory dwelling for the summer on account of its malarial surroundings, and had the satisfaction of seeing the volume appear. In November he served with Admirals Porter and Rowan on a board to fix the site of a naval station at Port Royal. On his return from this duty he had an attack of his old Mississippi complaint, chills and fever. His general health declined rapidly during the winter, and he died at the Naval Observatory in Washington on the 18th of February, 1877.

He had written from the Pacific in 1857, "I love the very stones in the streets of Cambridge," and so he was buried on the banks of the Charles river, within sight of the towers of the University, and in a spot which still retains its rural beauty. In the memorial hall of Harvard a stained glass window looks out directly upon the house in which his children were born and the scenes in which he walked familiarly through the happiest years of a useful life and records the fact that he was the oldest representative of the University and the senior in rank who served in the civil war.

To those who treasure the memories of his life his private virtues are a theme almost too sacred even for the memoirs of the august Academy which he helped to found. At home his charm and power lay in his keen intellect, unswerving integrity, and winning artlessness. The innocence of the dove, the wisdom of the serpent, these brought the inevitable compensation to his last years in "that which should accompany old age, as honor, love, obedience, troops of friends." In estimating his public character it is only fair to judge him by the light of his own times. No man attains eminence without making enemies in his own day, and Admiral Davis was no exception. Although a man of singular sweetness and evenness of temper, of absolute impartiality and freedom from prejudice in his relations toward men, he had his detractors and calumniators. It was sometimes said of him in the Navy that he had subordinated the regular duties of the profession to the pursuits of science. This is untrue. The battles of Port Royal Bay and Warsaw sound, of Fort Pillow and Memphis are an answer to this calumny. He took up scientific work at a time when the alternatives would have been total idleness or such occupations as the hunting of game or the rearing of chickens, and his detractors have been found among those who chose these. He entered the field of science when the gate stood wide open to him, and although not a man of genius, he went as far as a deep love of knowledge and truth and the talents which God had bestowed would carry him. Whatever he had to do he did with all his might; and so when the test came which sorted men according to the merit that was in them, the scientific officer went easily to the front and the idler dropped into oblivion. He passed the alembic of trying times.

So, as a naval officer, he must not be judged by the present standard. He had some qualities which were meritorious in his own time, such as his fearlessness of responsibility, self-reliance, and the independence of a sound judgment, upon which he was accustomed to depend. He served at a time when other virtues could be found in the service besides a blind subordination to printed regulations. There were no printed regulations in his day, and the Navy did well, because time-honored custom and the individual character of the officer stood instead. He was an admiral, not because he had attained a certain age, but because he was a flag officer and commanded fleets with which he fought and won battles. In short, he belonged to the past and his own time.

Von Holst has said that it will be easier for the next generation to picture the life of the ancient Egyptians than the social condition of its own grandfathers in this Republic in the first half of the nineteenth century. But if the political sins and passions of that era are as dead as the iniquities of the Pharaohs, so surely also some virtue has passed out with them, and Admiral Davis' lot was cast in the Navy when if ships were built of wood men were of steel. He was not pugnacious or quarrelsome, nor did he love fighting nor war for themselves, but he fought battles with exactly the same singleness of purpose with which he had run lines of soundings from Nantucket Shoals, and he wore his sword, not as an obsolete weapon, which might be an encumbrance in conflict with a person armed with a self-cocking revolver, but as a badge of his commission and the emblem of an almost forgotten honor.

MEMOIR

OF

JAMES EDWARD OLIVER.

1829-1895.

BY

G. W. HILL.

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BIOGRAPHICAL MEMOIR OF JAMES EDWARD OLIVER.

JAMES EDWARD OLIVER was born in Portland, Maine, on July 27, 1829. He was the third child of James Oliver, of Lynn, Massachusetts, and Olivia Cobb, of Portland. Professor Oliver's ancestry is traced back in more than one line to the earliest settlers of Massachusetts. However, in the exclusive male line it is not known beyond his great-grandfather and great-grandmother, Henry and Abigail Oliver, "of the Old Church" of Marblehead. His paternal grandparents were Henry Oliver, of Marblehead, and Ruth Newhall, of Lynn, who passed the whole of their married life in the latter town. Mr. Oliver followed the profession of a school teacher and had a family of eleven children, the youngest of whom was the father of Professor Oliver. Through his mother Professor Oliver was descended from Henry Cobb, who came from England (probably from Kent) to Plymouth, Massachusetts, in 1629, afterwards removing, in 1633, to Scituate, and again, in 1639, to Barnstable, where he died, in 1679. Being a man of note, he held influential positions in the churches of these towns, and served as representative from 1645 to 1651. As his second wife he married a daughter of Thomas Hinckley, the last governor of Plymouth Colony before its union with that of Massachusetts Bay. Through her descended Edward Cobb, the maternal grandfather of the subject of this notice.* Another ancestor was Robert Pope, who came from Yorkshire, England, in the ship *Mary and John*, of London, in 1634. Of him it is recorded that in 1658 he was punished for attending Quaker meeting.†

Professor Oliver was born during a short residence of his parents in Portland. They returned to Lynn, probably in 1832, and spent the remainder of their lives there, where the elder Mr.

*The given names of the line of Cobbs are Henry, Jonathan, Samuel, Samuel, Samuel, Edward.

†The line through this ancestor is Robert, Joseph, Samuel, Samuel, Robert, Elijah, Phebe, Olivia, James Edward.

Oliver filled the post of cashier of the then principal bank of the place. The family were attached to the principles of the Society of Friends, which doubtless accounts for the overdevelopment, as some would think it, in the line of ethics of the subject of our notice.

James Edward was not rugged as a child, and we hear that he passed through several illnesses which threatened his life. On this account he was not sent early to school, having attained the age of seven before this occurred. However, he made good progress at home, his mother being his instructor. For this duty she was the better qualified as having been before her marriage a teacher in a school at Providence, Rhode Island. "Mother's geography," as James called it, was the cyclopedia of useful knowledge from which he obtained the elements of the sciences. It was a small volume which now would be quite contemned. As one would suspect from James' subsequent career, he was remarkably precocious, although his attention in his early years was not especially attracted to mathematics, possibly because its literature was not thrown in his way. He was rather interested in general science and literature. From his mother he imbibed an interest in astronomy, this being a favorite study with her. On being sent to school, his first teacher was surprised to find how large a fund of information he had acquired on a variety of subjects usually unattractive to children.

As has been the case with so many endowed with an intense intellectuality, he was in early childhood an inordinate reader of books, so much so as to endanger his health. In consequence the family physician counseled his being taken into the country and deprived of them for a season. Here upon a farm, encouraged to pass the time out of doors with some playmates, his health improved; but he could not refrain from expressing his satisfaction at his return home for the reason, as he said, "In the house in the country they have no book but a Bible." This was read at family prayers, and all other books kept from him. At this time he was not more than six years old. All through his earlier years the weakness of his body disposed him to a lethargic habit; he was disinclined to take the exercise which might have imparted strength. It was not until he entered the academy in Lynn, where he prepared for college, that he became robust. His defect of nearsightedness prevented his enjoying the rough games of his schoolfellows; he preferred to remain indoors and pass the time allowed for play in reading, though he did enjoy swimming, running on the beach, and climbing about in the rock and barberry pastures and woods which abound in the vicinity of Lynn. A little later on, while he took little physical exercise, his muscles were strong, he could climb a tree, and astonished the men at the fire-engine house by climbing up and sliding down their pole.

While still a youth his morbid development on the ethical side, as it would be considered by those destitute of fine philanthropic feeling, led him to take an interest in the anti-slavery, temperance, and anti-tobacco reforms. In regard to the first, he even went to the length of rigorous abstinence from the use of all products of slave labor, whether food or clothing. The somewhat grotesque picture is drawn of him, at five or six years of age, standing upon the counter of his father's banking-room eloquently expostulating with a group of men addicted to tobacco-smoking or to too much wine. The audience, more amused than convinced, to soothe his feelings would sometimes pretend acquiescence, and some would go to the length of promising to change their habits. Great was his disappointment when he learned all this was but mere pretense. Farther on in life he learned that it was not a good plan to wear one's heart on one's sleeve; but, although boyish enthusiasm was succeeded by calm judgment, he always remained extremely faithful to his conscientious convictions. In later days he was on terms of intimacy with the noted anti-slavery leaders of eastern Massachusetts, and was regarded by them as an efficient helper in forming the public sentiment which eventually compelled the removal of this peculiar institution from our country.

It must not be gathered from this that he was at all obtrusive in debate, for he had at this early age the same retiring disposition he maintained through life, never assuming any airs of superiority on account of seniority or larger acquaintance with the subject discussed, but always placing himself on the intellectual level of those with whom he conversed. Rarely would he take the lead in conversation, leaving that to some one else of the company. He was as remote as possible from browbeating an opponent in argument, but very ready on all occasions to afford his help in untieing knotty questions.

In due course he was sent to the old Lynn Academy, a school more than a mile from his home. Here he prepared for college. The teacher of this institution at that time was Master Jacob Batchelder, commended as an excellent instructor by those who should know; no mere hearer of recitations, but one who stimulated his boys to independence of thought by his encouraging conversation—a rare sort of man in those days. Professor Oliver in after times always spoke of him with great gratitude and affection. Some ten years after his education at this academy ended, on March 12, 1856, a festival was granted to Mr. Batchelder by those who had enjoyed the benefit of his instruction. In Professor Oliver's poem for the occasion, printed in the local papers, are curiously joined poetic aspirations and description of former boyish sports about the old academy. Perhaps we may be pardoned for quoting the four concluding lines:

> "Be we knit by one purpose, though scattered;
> And where sin, wrong, oppression appear,
> Be the rallying cry rung through our phalanx—
> 'We, the children of Jacob, are here.'"

In 1846, at the age of seventeen, he entered Harvard College; passing into the sophomore class. Here we may suppose his attention was more particularly attracted to mathematics, the science he afterwards became famous in. We get the following characteristic picture of him and his connections at this period from the Hon. Horace Davis, formerly president of the University of California:

"Mr. Oliver was my room-mate during the last two years of my college course, and my close contact with him in this intimate relation brought me to a constantly increasing regard and respect for him. I never knew him until we met as classmates. He came from Lynn, his parents being old-fashioned Quakers. His father was cashier of a bank—a plain, straightforward man—and his mother a quiet, gentle lady, clad in the old-fashioned Quaker dress, with a calm, peaceful face, framed in old-style cap, such as was the fashion of that day. They lived over the bank, and there I used to visit them on Sundays, my father and mother being away much of the time in Washington.

"Oliver was a remarkable man in many respects. He had a strong individuality, amounting almost to eccentricity. He was sturdy and independent in his thought, determined and conscientious in his conviction, yet he was modest, retiring in his demeanor, and his extreme nearsightedness increased this tendency. He was liked by everybody in the class, but his intimate friends were few, and mainly among the boys from the country. He was studious in his habits, especially in those branches he was fond of, and he pursued these with an avidity which made him neglect other studies, for he cared very little for his rank. His first love, of course, was mathematics, and next to that came ethics and moral philosophy. His forensic compositions were especially terse and clear, but mathematics he devoured with an eager appetite, and when, in his senior year, he was given the *Mécanique Céleste* to study he would often become so absorbed as to prolong his work into the small hours of the morning, and I have many times waked up from my first nap to see him still poring over the ponderous volume long after midnight.

"One Sunday when I was at Lynn his good mother took me aside, full of maternal tenderness, and said to me in her quiet Quaker way: 'Davis, we know that James Edward sits up too late at night and we want thee to see that he goes to bed betimes.' 'But,' I said, 'Mrs. Oliver, James is older than I am and I have no authority over him.' 'Nay,' said the good old lady, 'but he has great respect for thee, and thee can give him some good counsel.' On our way back to Cambridge I opened to him his mother's remonstrances, and he promised he would keep better hours, though I knew it must have been much against the grain.

"My friend was an earnest reformer, and we often discussed the questions of the day, such as abolitionism and peace movements, during our long summer evening walks or on our Sunday strolls over the rocky hills and beside the beach at Lynn. He was too honest and sincere in his make to be anything but an abolitionist. To him no political necessity could disguise the inherent barbarity of slavery.

"There was in Oliver's composition a deep vein of poetry mingled with his mathematics, as is not uncommon. The class made him their class-day poet, and were so pleased with his poem that they printed it to take home with them, something unusual in those days.

"Oliver was also a man of deep religious convictions, not dogmatic, but broad and inclusive. His faith was firm and constant, and, wherever he went and whatever he did, he carried with him the consciousness of his Heavenly Father. In all my life I have never met a man who more sincerely lived up to his convictions, nor one in whom the milk of human kindness more thoroughly pervaded all his acts and life."

Professor Oliver graduated in 1849.

In the same year a new enterprise in astronomy was inaugurated in this country. Congress was persuaded to pass a bill creating a bureau of astronomical calculation. It was to be called the Office of the American Ephemeris and Nautical Almanac. Presumably Professor Benjamin Peirce and Admiral C. H. Davis were the prime movers in the matter. Nearly all the governments of western Europe, even that of so small a state as Portugal, published annually ephemerides of the principal heavenly bodies. It was represented that a proper regard for its dignity as a great civilized nation must lead the United States to follow this example; that our using an astronomical ephemeris published abroad was a subject of just reproach to us. By thus appealing to the national vanity of our legislators was this scheme made a success. No other argument would have served.

Mr. Oliver, having just graduated, naturally bethought himself of seeking some post in which his mathematical talents could be put to service. In this difficulty he sought counsel of his teacher, Professor Peirce, who proposed he should accept an assistantship in the Nautical Almanac Office, as doubtless the work would prove congenial to his taste. To this proposition Oliver readily acceded.

The office was established, in 1850, in Cambridge Massachusetts. This locality was selected because the neighboring libraries possessed a larger amount of astronomical literature than could be found at any other place in the country. Some of the assistants performed their work at the office, others at their homes, generally in the near neighborhood of Cambridge. Mr. Oliver was in the latter class. He lived at the home of his parents, on Green street, Lynn, where in his little study he did his work and received his friends. It was at this period of his in 1861, that I became acquainted with Mr. Oliver, meeting at the Nautical Almanac Office whenever he chose to visit us, which was about once a month. Coming in the morning, he would usually stay all day. The time was generally spent in discussing mathematical and astronomical subjects.

In spite of Professor Peirce's prediction, Oliver did not take kindly to the work necessitated by the publication of the American Ephemeris. He found the endless repetitions of the same arithmetical processes extremely wearisome. All that could be learned in this way was soon exhausted and the interest attached to the novelty of the work soon worn threadbare. It soon became drudgery to him, and he would rather have devoted his energies to original research in higher algebra. At the time I first met him I remember his conversation at the office was plentifully interlarded with the words *quantics*, *invariants*, *covariants*, *discriminants*, and the like. When Oliver began to discourse eloquently on these things, I remember distinctly that the rustling of the leaves of the tables of logarithms would cease, and did not commence again until he got through. It was a very great pity that a man having this exalted enthusiasm for exploration in the higher mathematics should be condemned to waste a large portion of his energy in work which might have been performed by one of small talents. However, it speaks volumes for the patience of Oliver that he remained attached to the Office for a period which must have exceeded fifteen years.

But, while the greater part of Oliver's time was devoted to mathematical and astronomical work, he still found opportunity for exerting himself in other lines. At this time, 1852, he appears as one of the founders of the Young Men's Debating Club, an association that existed through the following seven years. In this, politics, especially the slavery question, received a large share of attention. Mr. Oliver took a leading part in the literary exercises of this society, which included a manuscript journal. To this his frequent contributions gave a character at once original and unique, and for a time he was its editor.

We learn that in 1891 there was a reunion of the survivors of this club in Lynn. Mr. Oliver was present and made the marked address of the gathering. At the request of members it was afterwards printed. It was a well-thought-out presentation of the outlook of humanity in the ethical direction. In this connection I well remember, about the time I first met him, how engrossed a student he was of the writings of John Ruskin.

Caring little for the art theories of this author, he was yet profoundly impressed with his transcendental views of ethics.

In 1867 the Nautical Almanac Office was removed from Cambridge to Washington, and about this time Oliver severed his connection with it. In the autumn of 1868 he went to New York and remained until the following spring. While there it appears he pursued the study of some branches of applied science at the School of Mines of Columbia College. Although he had given up his salaried position in the Nautical Almanac he still made computations for it, working far into the night after spending a pleasant social evening with friends who boarded in the same house, a literary coterie, comprising C. C. Stedmen, R. H. Stoddard, J. M. Hart, Haven Putnam the publisher, Dr. J. Winslow, and others.

In 1869, at the suggestion of his friend and brother-in-law, Pliny Earle Chase, he went to Philadelphia. I remember meeting him at this time at the room of Chauncey Wright in Cambridge. He said he was going to Philadelphia to study chemistry. Of course, we were all regretting that mathematics should lose him. But we hear that he and Pliny Earle Chase studied philosophy and mathematics together and enjoyed themselves greatly at the social gatherings held for discussion and exchange of ideas on Sunday evenings at the house of Professor J. P. Leslie. While in Philadelphia he also engaged in giving private instruction to pupils in the usual English and classical branches, especially in mathematics and physics.

Having returned to Lynn at the end of 1870, in the following spring he gave a course of lectures on thermodynamics at Harvard University. It was his intention to continue these by lectures, to be given in the autumn, on physiological optics; but this plan was frustrated by his acceptance of an assistant professorship of mathematics at Cornell University. Repairing to Ithaca he fulfilled the duties of this station until, on the death of Professor E. W. Evans in 1873, he was made senior professor of mathematics. In this post of duty he spent the remainder of his life.

During the twenty-four years he was connected with Cornell University he appears to have entered into a great variety of work. In the early part of his career there he was under the necessity of giving much time to junior courses in mathematics;

but after 1889 his work was chiefly in post-graduate courses, where he was more in his element. The range of subjects covered by Professor Oliver in his lectures in different years is certainly remarkable: Analytic Geometry, Infinitesimal Calculus, Quaternions, Definite Integrals, Spherical Harmonics, Elliptic Functions, Theory of Probabilities, Theory of Functions, Abelian and Automorphic Functions, Finite Differences, Factorials and Difference Equations, Differential Equations, Non-Euclidean Geometry, Celestial Mechanics, Mathematical Optics, Mathematical Theory of Electricity and Magnetism, Mathematical Pedagogy. It is stated that in the same year he often lectured on as many as seven of these subjects. He would frequently write at the rate of one new lecture a day (skeleton notes, be it understood, sufficient to guide him in the delivery of it).

He was fond of applying mathematics to out-of-the-way subjects. Thus he attempted the illustration of the science of economics by the employment of algebraic formulas. While at Cornell he established a seminarium in economics. Several previous investigators had made a beginning in this line. Professor Oliver's aim was to define the relation between the theory of probabilities and economic laws. The difficulty in the way seems to be the exceeding complexity of the motives which urge men to the carrying out of economic actions, which refuses to be submissive to formulation. It is a like state of things to that which prevents us from predicting the weather as we do astronomical phenomena. One recalls the fate of Poisson's Probability of Judicial Decisions, which the author hoped would be of material assistance to legislators in settling the forms of criminal jurisprudence, but which has remained interesting only as a *tour de force* of scientific speculation.

Professor Oliver would also apply mathematics to physiological and psycological questions. Thus we find him in 1892 writing a paper entitled "A Mathematical View of Free Will." He even would weigh happiness in the scales of mathematics.

But Professor Oliver spent too much time in lecturing; during term time it amounted from fifteen to twenty hours a week. There was left him little time or energy for research outside the class-room. During vacation time he often began some subject for a memoir, but the end of the vacation would arrive before he had finished it, and he must again attend to his classes. By the next vacation his thoughts had drifted off into new channels. It is much to be regretted that some at least of his lectures were not taken down in shorthand at the time of their delivery by an auditor, as is now so often done in Europe, that we might have had specimens of his methods of treatment of subjects. He appears to have depended much more on verbal illustrations and explanations than the generality of lecturers on mathematics, and consequently his audience were pleased to find they could follow him. All have spoken with admiration of him in this respect. He was addicted to dilating at considerable length on the connections of his subject with cognate branches. He did not think it worth while to bewilder his audience with a great mass of formulas written on the blackboard. Rather than carry the attacked place by assault he preferred to draw his parallels of steady approach by the art of the engineer. His lectures were rather talks about than treatises on the subjects taken in hand.

While at Cornell, in conjunction with Professors Wait and Jones, he wrote and published text-books on algebra and trigonometry. Of the first, the chapter on imaginaries is more especially his work.

We have a few details as to his habits during the earlier years of his connection with the university. He was noted for sitting up late at night, or all night, absorbed in his work, and for forgetting to go for his meals. When he had got fairly plunged into the depths of some investigation he was quite oblivious of the flight of the hours, and he was like a hound which can scarcely be torn from the pursuit of the scent. With him the spirit was everything; the flesh counted almost for nothing. The picture is drawn of him hurrying over the college campus, taking now and then a bite out of a cracker for all breakfast that morning, for lecture time had arrived before he could bestow one thought on the meal. One is reminded of the playful allusion of Plato in the "Phædrus" to the custom of the ancient Athenians of wearing a golden cicada as an emblem of their claim to be *autochthones:* "It is said these insects were men before the discovery of the musical arts. But on the advent of music and the appearance of poetry they were so overcome by the pleasure of this occupation that, singing, they became heedless of food and drink, and thus, quite unawares to themselves, they passed away." As these habits were seen to be undermining his health, his sister came to Ithaca to put a stop to them. Later, his wife kept him to a more moderate measure of study.

In 1888, after we had long set him down as a confirmed bachelor, he married Miss Sarah T. Van Petten, a teacher of Oswego, who survives him. In the following year, accompanied by Mrs. Oliver, he crossed the Atlantic, with the main purpose of seeing for himself the modes of teaching mathematics followed at the European universities. His stay in Europe amounted to fourteen months; it was passed mainly at the universities of Cambridge and Göttingen. In the earlier part of his mathematical career Professor Oliver had largely devoted himself to modern algebra, created in great measure by Professor Cayley. On his arrival in Cambridge he anticipated great enjoyment from seeing Professor Cayley and hearing him lecture. At this time Professor Cayley was quite feeble, although he was still lecturing. Professor Oliver heard his lectures and had some conversation with him, but felt obliged to curtail the latter for fear of fatiguing him. At Göttingen he found a congenial friend in Professor Klein. In a note written from there he says: "My work here is likely to be of great service to me, including the trains of thought and plans it suggests, no very radically new plans, only as to the spirit, the aims, and the details of my Cornell work."

After Professor Klein returned from the mathematical Congress at Chicago, in 1893, he visited Professor Oliver at Ithaca, and we learn that the two professors, in walking through one of the beautiful ravines which abound in that vicinity, discussed the glimpses given by mathematical studies into the view of the probable immortality of the soul.

Professor Oliver's friends were hoping that he had still before him many years of active life in which he might complete and publish for our gratification some of his numerous investigations, but this hope, taken in the mundane acceptation, was not to be realized. Stricken with a serious illness early in 1895, after battling with it for ten weeks, he succumbed and passed away March 27, 1895, to the great regret of all who knew him, even of those who had the slightest acquaintance with him.

In estimating the importance of Oliver's work in mathematics it must be borne in mind that his published papers are a mere drop from the full bucket. They were thrown off in the hurry of the moment and seem merely the result of the byplay of his mind. All the efforts of his friends to tie him down to a sustained labor in one direction until rounded completion was reached were unavailing. He seemed to have a constitutional dislike to arranging and writing out in due form the material of a subject he had previously made himself master of; the impulse with him was to press on to something new; he could not delay to paint the fine scene he had witnessed, he could not resist the temptation to see what more might be found in the distance. Stimulus from ambition he could obtain none, for this passion had been left out of his composition; in the matter of procuring fame for himself he was utterly careless. Could he have been induced to write a book worthy of himself he would have done it purely for the gratification of others, heedless whether it brought him any credit. His ardently pursued researches into science seem to have been undertaken from one of two motives, either he loved the thing for its own sake, or he was swayed by a far-fetched philanthropic impulse incomprehensible to the ordinary prosaic mind. Let Plato describe for us the latter motive: "What are the needful sciences? I conceive, those which, having never learned or practiced, one can never become a god or demon or hero for man, of such a quality as to be able to take charge of them with zeal." "When they have light they will share it with one another."

But, although the penning of his thoughts was distasteful to Oliver, he was ready enough to talk about the matters he was conversant with. And how many of them there were. You could scarcely start any scientific or literary subject for discussion in his presence but he appeared as ready and equipped as if it had formed the sole object of his thoughts for years. It seemed that there was no way of explaining this but that he must have had a previous stage of existence, in which he had accumulated this vast store of information, and that in his passage to this life he had been allowed to retain it; but he had the rare faculty of seeing at a glance what are the salient and controlling elements of a subject and could thus dispense with learning the minute details. From one point he divined the lay of the land, while ordinary mortals must traverse it hither and thither in many directions to obtain as exact a conception. He was the Socrates of mathematics, and in de-parting from Cornell his pupils carried away with them the inspiriting influences he had exerted upon them in many lines.

But to describe Oliver as a mathematician and scientist solely would be to miss more than half the man. He seemed to be actuated by two passions; it was impossible to tell which was the more intense. For a time he would be under the influence of one, and then the other came to the front. One, of course, was his passion for the study of mathematics, the other was his passion for the study of ethics. He was a man of wide sympathies and many subjects engaged his attention, but these two were by far the principal, the rest, in comparison, were mere by-play. It is needful here to explain the word "ethics" lest there should be a misapprehension. In fine-spun theories of duty he had only a trifling interest. Such a book as Aristotle's Nicomachean Ethics he would have but glanced at, and the formal text-books on the subject were of little aid to him. In this mental dearth he resorted to the poets. He was especially fond of those who have depicted the moods of the spirit. His favorites were Shakespeare, the "In Memoriam" of Tennyson, Robert Browning, and his friend J. G. Whittier. He was no despicable poet himself. When a schoolboy, as often as permitted, his attempts at literary composition were in verse. In later years he occasionally though rarely indulged himself in poetic composition.

Oliver regarded his soul as a stringed musical instrument upon which he was to play. He was always engaged in experimenting upon the tension of its strings, that he might elicit from it a more and more exquisite and ravishing music. His aim was to put it in harmony, closer and still closer, with the music of the spheres:

> "Sit, Jessica; look how the floor of heaven
> Is thick inlaid with patines of bright gold;
> There's not the smallest orb which thou behold'st
> But in his motion like an angel sings,
> Still quiring to the young-eyed cherubins:
> Such harmony is in immortal souls;
> But, while this muddy vesture of decay
> Doth grossly close us in, we cannot hear it."

It was his delight to be strung to the highest key. He cared nought for his animal existence, but he wanted to climb to the highest plane of intellectual and spiritual life it was possible for man to reach. This was why he pursued with such avidity ethical studies.

In all this there was not the slightest tinge of religious asceticism or superstition. He had no creed, no set cultus; he could not be assigned to any sect. He was so bent on soaring into the upper regions of the intellect and spirit that he could not bear to be clogged with chains of any sort, not even those of a religious nature, which others take as ballast. He was a man in whom theology is swallowed up of philanthropy and philosophy. He was born in the Society of Friends, but I never saw him in Quaker garb or heard him use the Quaker phraseology or utter a single syllable of theology.

When he had removed to Ithaca and it became known that he was affiliating with the Unitarian Society there, there went abroad among the Quakers of Lynn the faintest whisper, "Oliver has forsaken the faith of his fathers." Faint as the whisper was, it nevertheless after a time reached his ears. Such a remark could not trouble his serenity; but he thought it too bad these good people, for whom he always retained the kindliest feelings, should be disturbed by such an impression. He accordingly sat down and wrote a letter, addressed to the society, in which he maintained the fundamental Quaker doctrine of the supremacy of the inner light over all traditional authority. He set forth his views and the leadings of the light within him. He asserted he had not swerved from the path followed by his fathers; that he had simply gone further along it, and that consequently new vistas had opened to him. So great was the pathos and so cogent the logic of this letter that that faint note of detraction was never heard thereafter.

Liberal of an advanced type as Oliver was, he had no tincture of the *odium theologicum*, nothing of the embittered attitude of Salvator Rosa, who said, "If there is anything I take pride in, it is that I despise the church and her priests." He was as ready to find good in Buddhism or Brahminism or Platonism as in Christianity. At Cornell, although reluctant to submit himself to the slightest trammels of organization, he yet so far yielded as to take part in the labors and fellowship of the Unitarian church there. In these he bore a prominent part and conducted the large class in ethics connected with the society and frequented by many young men and women from the university. Here his luminous treatment of this subject will long be remembered by his auditors.

With Oliver there was no distinction between things sacred and secular. He did not have one code of morals for Sunday and another for the rest of the week. With truth he might have applied to himself the lines of Thoreau, halting, but full of significance:

> "I cannot come nearer to God and Heaven
> Than I live to Walden even."

There are some to whom this seems a worship of the creation in preference to the Creator; but Wisdom is justified of all her children.

The testimony to Professor Oliver's moral and social excellence is uniformly to the same effect, and is couched in such extravagant terms that one is afraid it cannot be believed by those who did not know him; yet I do not think it is at all exaggerated. Suffice it to quote one example from one of Oliver's colleagues at Cornell:

"He did not accept the orthodox view of Jesus, but I never knew a better, more lovable man than Professor Oliver. And his goodness was so spontaneous. It was the set of his being. He seemed to me to be almost without sin."

In the southern part of Syria, in a remote antiquity, it was the custom of the people to worship the local or tribal deity in the shade of the groves on the tops of the mountains. A poet of that time and country has described in a few lines his conception of the character of the man who should be permitted to take part in this worship. These lines are remarkable as containing the sum and substance of all that can be set forth regarding rectitude of human conduct; for loftiness of sentiment they have never since been equaled. I quote them because they seem eminently characteristic of our confrère Oliver:

> "Who shall ascend into the mountain of Yahveh?
> Who shall stand in his holy place?
> He that hath guiltless hands
> And a pure heart,
> Who hath not wasted his life in folly,
> Nor sworn deceitfully to his fellow.
> He shall receive blessing from Yahveh,
> And help from the god his saviour.
> This is the clan of those that seek him,
> That seek the face of the god of Jacob."

List of the Published Scientific Papers of James Edward Oliver.

Demonstration of the Pythagorean Proposition: *Math. Monthly*, vol. i, 1858.

On Mr. Collins' Property of Circulates: *Ibid.*

Introduction to a Treatise on Determinants: *Ibid.*, vol. iii, 1860.

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Partial Investigation on Best Approximate Representation of Mutual Ratios of k Quantities by those of Simple Integers: *Proc. Am. Acad. of Arts and Sciences*, vol. vi, May 10, 1864.

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On the Law of Distribution for Certain Plant Numbers: *Proc. Am. Ass. Adv. Sci.*, vol. xxxi, 1882.

A Method of Finding the Law of Linear Elasticity in a Metal: *Ibid.*

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A Singular Optical Phenomenon: *Science*, vol. iii, pp. 475, 563, 1884.

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Elementary Notes. I. General and Logico-Mathematical Notation: *Ibid.*, vol. iv, 1888.

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Short Notes on the Soaring of Birds: *Science*, January 4, 1889, etc.

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Some Difficulties in the Lesage-Thomson Gravitation Theory: *Proc. Am. Ass. Adv. Sci.*, 1892.

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MEMOIR

OF

FIELDING BRADFORD MEEK.

1817-1876.

BY

CHARLES A. WHITE.

READ BEFORE THE NATIONAL ACADEMY, NOVEMBER, 1896.

BIOGRAPHICAL MEMOIR OF FIELDING BRADFORD MEEK.

Mr. President and Members of the Academy:

As no formal memoir of Mr. Meek has been presented to the Academy, although it is now twenty years since he died, I offer the following sketch for our archives. It is necessarily brief, because he was himself very reticent concerning all his personal affairs, even with his intimate associates, and because he had survived all his relatives except a few who were comparative strangers to him, and he to them. It was my good fortune to be acquainted with him during the last ten or twelve years of his life and to be admitted to a large share of his confidence. While engaged with him in some paleontological studies a few months before his death I seized upon an unusually favorable occasion to obtain from his own lips the following biographical data:

Mr. Meek was born in the city of Madison, Indiana, December 10, 1817. The ancestral home was in county Armagh, Ireland. His grandparents, who were communicants of the Irish Presbyterian church, emigrated to America about the year 1768, and made their new home in Hamilton county, Ohio. There his father grew up to manhood and married; but a few years afterward, with his young family, he removed to Madison, where he became a lawyer of considerable eminence. The family, including the children born in Madison, consisted of the parents, two sons, and two daughters, all of whom were dead many years before Mr. Meek's own decease. The father died when Fielding was only three years old, leaving the family in only moderate circumstances.

Fielding's early youth was spent in the city of his birth, where he attended the best schools that were then established there, but his ill health greatly interfered with his education. Still, the time of those years was not wasted, for it was then that he began to develop a love for natural science, by his contributions to which he afterward became distinguished. Upon reaching manhood, by advice of his friends but against his own inclination, he invested his small patrimony in a mercantile business, first in Madison and afterward in Owensboro, Kentucky. The result was financial failure. After this he labored at whatever he could find to do, struggling with poverty and ill health, but improving every opportunity to advance his studies, which then began in earnest to include the fossils found in the region of his home. His earnestness in this direction drew the attention of Dr. D. D. Owen, who, when he began to organize his United States Geological Survey of Iowa, Wisconsin, and Minnesota, made young Meek one of his assistants. He held that position during the years 1848 and 1849, at the end of which time he returned to Owensboro.

He remained in Owensboro until 1852, when he went to Albany, New York, as assistant to Prof. James Hall in the paleontological work of that State. He entered upon this work with zeal and effectiveness, for he had then not only acquired large knowledge of invertebrate fossils, but he had become very skillful with his pencil in their delineation. With the exception of three summers, he remained at Albany continuously until 1858. Two summers were spent upon the Geological Survey of Missouri, under the direction of Prof. G. C. Swallow, and the other, that of 1853, in exploring the Bad-lands of Nebraska. In this work he was associated with Dr. F. V. Hayden, both of them having been commissioned by Professor Hall to do that work in his interest.

Three years after that exploration he, in collaboration with Professor Hall, prepared for publication by the American Academy of Arts and Sciences of Boston an important memoir on Cretaceous fossils from Nebraska. This was his first published paleontological work, and it was a worthy introduction to his subsequent career.

In 1858 Mr. Meek left Albany and went to Washington, D. C., where he resided until his death. The main building of the Smithsonian Institution had then been only a short time completed and all its rooms were not then needed for its business. The Secretary, Professor Henry, who encouraged the gathering at the Institution of scientific workers, not only gave them all its advantages for study, but he allotted some of the unoccupied rooms as sleeping apartments to such as were without a family. One of these rooms, situated in the main tower, was allotted to

Mr. Meek when he first went to Washington, and it remained his only home, as well as his usual working place, until his death.

The association which he formed with Dr. Hayden in their western explorations in 1853 was at least tacitly continued as long as Mr. Meek lived. All the invertebrate fossils collected by Dr. Hayden in his afterward famous western explorations were investigated and prepared for publication by Mr. Meek, although a large part of the results of those labors was published under the joint name of Meek and Hayden. In the principal work which was published under this partnership name, "The Paleontology of the Upper Missouri," Mr. Meek evinced a high order of paleontological ability, and the reputation thus gained was well sustained by his subsequent work.

Notwithstanding his intimate relation with Dr. Hayden, Mr. Meek declined to accept any regularly salaried position upon the survey organized by the former, preferring to command his own time and opportunities to do work in other inviting fields. He thus did for the Geological Survey of Illinois much the greater part of the work on invertebrate fossils which has made that series of reports famous, although it was published under the joint name of Meek and Worthen.

The appended list shows the extent of Mr. Meek's labors, and therefore mention will be made here only of his last one, which he justly regarded as the most important work of his life. It is volume ix of the quarto series of the United States Geological Survey of the Territories, and contains more than 600 pages of text and 45 full-page plates of illustrations.

Because twenty years have passed since Mr. Meek finally laid down his pen, and because his work is now held in as high esteem as when he was alive, it is unnecessary to speak at length here of its character. It is enough to say that it was characterized by thoroughness, scrupulous exactness, nice power of discrimination, and a comprehensive grasp of his subject.

Mr. Meek was never robust in health, and during a large part of his life he was more or less an invalid, his malady having been pulmonary tuberculosis. As age advanced his periods of exhaustion became more frequent and more pronounced until they ended in death. He died in Washington December 21, 1876, having only a few days before completed his 59th year.

His funeral was held in a hall of the Smithsonian building, where Professor Henry delivered a funeral oration, and the burial was made in the Congressional cemetery, in the eastern suburb of Washington.

In person Mr. Meek was moderately tall, rather slender, and of dignified bearing. Although he was never strong and often ill he never complained, was always cheerful, always hopeful, and always passionately devoted to his scientific work. He was genial, sincere, pure-minded, and honorable. Gentleness and candor were apparent in every lineament of his face and in every word he uttered; yet he was eminently self-reliant and rigorously circumspect in all his actions. His hearing began to fail in early manhood, and the infliction increased until he became totally deaf several years before he died, so that his friends could converse with him only by writing. This affliction, together with his natural diffidence, caused him to avoid social gatherings, but he was always ready, and even eager, to meet and converse with his friends, especially those who were engaged in kindred studies.

He was never miserly, but his habits were so frugal that at the time of his death he had accumulated what to him was a comfortable provision for old age. He seemed to have had no morbid fear of death, but none of his friends, not even Professor Henry, who had great influence with him, could induce him to make his will. The result was that his accumulations went to a distant relative, who was a comparative stranger to him in life.

Few men will be remembered, both for eminent ability and sterling personal qualities, so long as Fielding Bradford Meek.

The following is a list of his writings, arranged chronologically:

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Meek, F. B., and Hayden, F. V.—Descriptions of new species of Gasteropoda from the Cretaceous formations of Nebraska Territory. <Proc. Acad. Nat. Sci. Philad., vol. viii, pp. 63–69. Philadelphia, 1857.

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MEMOIR

OF

CHARLES EDOUARD BROWN-SÉQUARD.

1817-1894.

BY

H. P. BOWDITCH.

READ BEFORE THE NATIONAL ACADEMY, APRIL, 1897.

BIOGRAPHICAL MEMOIR OF CHARLES EDOUARD BROWN-SÉQUARD.

CHARLES EDOUARD BROWN-SÉQUARD was born at Port Louis, Mauritius, on the 8th of April, 1817. He died at Paris on April 2, 1894. He was a posthumous child of a Philadelphia sea captain named Brown and a French lady, born at Mauritius, named Mlle. Séquard. Little is known of his early life, except that during his childhood his mother supported herself and him by the work of her needle. At fifteen years of age he was employed as clerk in a large colonial warehouse. During this period of his life he made some excursions into the domain of literature with considerable local success, and when in 1838 he embarked with his mother for France he took with him a manuscript novel and a letter of introduction to Charles Nodier. Nodier discouraged the youthful aspirant for literary honors and advised him to devote himself to a pursuit by which he could earn his living. It is a curious coincidence that Brown-Séquard's illustrious predecessor, Claude Bernard, had a similar experience when, bearing the manuscript of a five-act tragedy, he presented himself before Saint Marc Girardin. It is interesting to speculate whether letters have lost as much as physiology has gained in this change of career of two eminent men of science. Disappointed in his hope of acquiring literary fame, Brown-Séquard devoted himself to the study of medicine, but was much delayed in the prosecution of his studies by a dissecting wound, which interrupted his work for many weeks, and by the death of his mother, to whom he was passionately devoted. This latter event produced such a profound impression upon him that he was for a long time absolutely incapable of work. At this period he began the wandering life which has always been so characteristic of him, and which is without parallel in the life of any scientific man. It was not till 1846 that he obtained the degree of Doctor of Medicine. His thesis was on the physiology of the spinal cord, a subject to which he has always devoted a large amount of attention. Shortly afterward we find him employed in the military hospital of Gros Caillou during the cholera epidemic of 1849. About this time he became one of the founders of the Société de Biologie.

Having fought for the liberties of the citizens at the time of the coup d'état of 1852, he naturally feared that he might be molested by the authorities, and he therefore embarked for America in a sailing vessel, trusting that the length of the voyage would afford an opportunity of learning the English language. It is difficult and unnecessary to follow the steps of Brown-Séquard's erratic career for the next sixteen years. Suffice it to say that he was continually crossing the Atlantic ocean, each time apparently hoping to establish a home for himself in the city of his choice. During this period he practiced and taught his profession in Richmond, New York, Boston, Glasgow, Edinburgh, Dublin, London, and Paris. Wherever he lived his ardor for research and study never slackened; even on his voyages he continued to devote his time to the investigation of the objects around him.

In 1878 he was called upon to succeed Claude Bernard in the chair of experimental medicine of the Collége de France. From that time until his death he remained in France, active in the prosecution of his chosen science. How great was his activity during this period of his life is amply proved by the pages of the Comptes rendus de la Société de Biologie and by those of the Archives de Physiologie, in which most of his researches were published.

Although Brown-Séquard was active in nearly all departments of physiology in the course of his lengthy career, his most important work was neurological. Among the problems to the solution of which his work was especially directed may be mentioned: the course of the motor and sensory channels in the spinal cord, the influence of the vaso-constrictor nerves over the blood-vessels, the artificial production of epilepsy and the inheritance of the same. His work upon the so-called "Elixir of life," which was received with so much incredulity by most physicians, gave an important stimulus to the study of the internal secretion of glands, a branch of physiology which gives promise of leading to important advances in therapeutics.

A tireless collector of facts, if his reasoning power had equaled his power of observation he might have done for physiology what Newton did for physics. He, however, lacked the gift of philosophic analysis and the power of estimating at their true value the various observations made by himself and others. He taught that the connections of the central nervous system are such that every part may produce in every other part either an increase or a diminution of its activity. With regard to vision, for instance, he maintained "that a disease in one-half of the brain can produce hemiopia either of both eyes or one and in the corresponding or the opposite halves of the retinæ, or a complete amaurosis of either of the two eyes or of both together." The extreme complexity of the phenomena manifested in the central nervous system goes far toward justifying these views, but theories of this sort can, of course, never be fruitful, for they destroy all hope of making physiology a basis of diagnosis and treatment of disease.

Although Brown-Séquard made many important discoveries, it is perhaps not too much to say that one of his strongest claims to remembrance rests upon the stimulus to research which flowed from his activity in the various medical communities in which he resided and on the enthusiasm for pure science which he imparted to all who came into personal relations with him.

MEMOIR

OF

HUBERT ANSON NEWTON.

1830-1896.

BY

J. WILLARD GIBBS.

READ BEFORE THE NATIONAL ACADEMY, APRIL, 1897.

BIOGRAPHICAL MEMOIR OF HUBERT ANSON NEWTON.

HUBERT ANSON NEWTON was born on March 19, 1830, at Sherburne, N. Y., and died at New Haven, Conn., on the 12th of August, 1896. He was the fifth son of a family of seven sons and four daughters, children of William and Lois (Butler) Newton. The parents traced their ancestry back to the first settlers of Massachusetts and Connecticut,* and had migrated from the latter to Sherburne, when many parts of central New York were still a wilderness. They both belonged to families remarkable for longevity, and lived themselves to the ages of ninety-three and ninety-four years. Of the children, all the sons and two daughters were living as recently as the year 1889, the youngest being then fifty-three years of age. William Newton was a man of considerable enterprise, and undertook the construction of the Buffalo section of the Erie canal, as well as other work in canal and railroad construction in New York and Pennsylvania. In these constructions he is said to have relied on his native abilities to think out for himself the solution of problems which are generally a matter of technical training. His wife was remarkable for great strength of character, united with a quiet temperament and well-balanced mind, and was noted among her neighbors for her mathematical powers.

Young Newton, whose mental endowments were thus evidently inherited, and who early manifested the natural bent which directed his life, fitted for college at the schools of Sherburne, and at the age of sixteen entered Yale College, in the class graduating in 1850. After graduation he pursued mathematical studies at New Haven and at home, and became tutor at Yale in 1853, when, on account of the sickness and death of Professor Stanley, the whole charge of the mathematical department devolved on him from the first.

* Richard Butler, the great-grandfather of Lois Butler, came over from England before 1633, and was one of those who removed from Cambridge to Hartford. An ancestor of William Newton came directly from England to the New Haven Colony about the middle of the same century.

In 1855 he was appointed professor of mathematics, at the early age of twenty-five, a position which he filled until his death. This appointment testifies to the confidence which was felt in his abilities, and is almost the only instance in which the Yale Corporation has conferred the dignity of a full professorship upon so young a man.

This appointment being accompanied with a leave of absence for a year, in order to give him the opportunity to study in Europe, it was very natural that he should be attracted to Paris, where Chasles was expounding at the Sorbonne that modern higher geometry of which he was to so large an extent the creator, and which appeals so strongly to the sense of the beautiful; and it was inevitable that the student should be profoundly impressed by the genius of his teacher and by the fruitfulness and elegance of the methods which he was introducing. The effect of this year's study under the inspiring influence of such a master is seen in several contributions to the *Mathematical Monthly* during its brief existence in the years 1858–'61. One of these was a problem which attracted at once the attention of Cayley, who sent a solution.* Another was a discussion of the problem "to draw a circle tangent to three given circles," remarkable for his use of the principle of inversion.† A third was a very elaborate memoir on the construction of curves by the straight edge and compasses, and by the straight edge alone.‡ These early essays in geometry show a mind thoroughly imbued with the spirit of modern geometry and skillful in the use of its methods, as well as eager to extend the bounds of our knowledge.

Nevertheless, although for many years the higher geometry was a favorite subject with Professor Newton for the instruction of his more advanced students, either the natural bent of his mind, or perhaps rather the influence of his environment, was destined to lead him into a very different field of research. In the attention which has been paid to astronomy in this country we may recognize the history of the world repeating itself in a new country in respect to the order of the development of the sciences, or it may be enough to say that the questions which

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* Mathematical Monthly, vol. i, p. 2.
‡ *Ibid*, vol. i, p. 239.
‡ *Ibid*, vol. iii, pp. 235 and 268.

nature forces on us are likely to get more attention in a new country and a bustling age than those which a reflective mind puts to itself, and that the love of abstract truth which prompts to the construction of a system of doctrine, and the refined taste which is a critic of methods of demonstration, are matters of slow growth. At all events, when Professor Newton was entering upon his professorship the study of the higher geometry was less consonant with the spirit of the age in this country than the pursuit of astronomical knowledge, and the latter sphere of activity soon engrossed his best efforts.

Yet it was not in any of the beaten paths of astronomers that Professor Newton was to move. It was rather in the wilds of a *terra incognita*, which astronomers had hardly troubled themselves to claim as belonging to their domain, that he first labored to establish law and order. It was doubtless not by chance that he turned his attention to the subject of shooting stars. The interest awakened in this country by the stupendous spectacle of 1833, which was not seen in Europe, had not died out, as is abundantly shown by an inspection of the indexes of the American Journal of Science. This was especially true at New Haven, where Mr. Edward C. Herrick was distinguished for his indefatigable industry both in personal observation and in the search for records of former showers. A rich accumulation of material was thus awaiting development. In 1861 the Connecticut Academy of Arts and Sciences appointed a committee "to communicate with observers in various localities for combined and systematic observations upon the August and November meteors." In this committee Professor Newton was preëminently active. He entered zealously upon the work of collecting material by personal observation and correspondence and by organizing corps of observers of students and others, and at the same time set himself to utilize the material thus obtained by the most careful study. The value of the observations obtained was greatly increased by a map of the heavens for plotting meteor-tracks, which was prepared by Professor Newton and printed at the expense of the Connecticut Academy for distribution among observers.

By these organized efforts, in a great number of cases, observations were obtained on the same meteor as seen from different places, and the actual path in the atmosphere was computed by

Professor Newton. In a paper published in 1865 the vertical height of the beginning and the end of the visible part of the path is given for more than one hundred meteors observed on the nights of August 10 and November 13, 1863. It was shown that the average height of the November meteors is fifteen or twenty miles higher than that of the August meteors, the former beginning in the mean at a height of ninety-six miles and ending at sixty-one, the latter beginning at seventy and ending at fifty-six.*

We mention this paper first because it seems to represent the culmination of a line of activity into which Professor Newton had entered much earlier. We must go back to consider other papers which he had published in the mean time.

His first papers on this subject, 1860–'62,† were principally devoted to the determination of the paths and velocities of certain brilliant fire-balls which had attracted the attention of persons in different localities. Three of these appeared to have velocities much greater than is possible for permanent members of the solar system. To another particular interest attached as belonging apparently to the August shower, although exceptional in size. For this he calculated the elements of the orbit which would give the observed path and velocity; but the determination of the velocity in such cases, which depends upon the estimation by the observers of the time of flight, is necessarily very uncertain, and at best can afford only a lower limit for the value of the original velocity of the body before it encounters the resistance of the earth's atmosphere. This would seem to constitute an insuperable obstacle in the determination of the orbits of meteoroids, to use the term applied to these bodies before they enter the earth's atmosphere and appear for a moment as luminous meteors. Yet it has been completely overcome in the case of the November meteoroids or Leonids, as they are called from the constellation from which they appear to radiate. This achievement constitutes one of the most interesting chapters in the history of meteoric science, and gives the subject an honorable place among the exact sciences.

In the first place, by a careful study of the records, Professor

*Amer. Jour. Sci. (2), vol. xl, p. 250.

†Amer. Jour. Sci. (2), vol. xxx, p. 186; vol. xxxii, p. 448; vol. xxxiii, p. 338.

Newton showed that the connection of early showers with those of 1799 and 1833 had been masked by a progressive change in the day of the year in which the shower occurs. This change had amounted to a full month between A. D. 902, when the shower occurred on October 13, and 1833, when it occurred on November 13. It is in part due to the precession of the equinoxes, and in part to the motion of the node where the earth's orbit meets that of the meteoroids.

This motion must be attributed to the perturbations of the orbits of the meteoroids, which are produced by the attractions of the planets, and, being in the direction opposite to that of the equinoxes, Professor Newton inferred that the motion of the meteoroids must be retrograde.

The showers do not, however, occur whenever the earth passes the node, but only when the passage occurs within a year or two before or after the termination of a cycle of 33.25 years. This number is obtained by dividing the interval between the showers of 902 and 1833 by twenty-eight, the number of cycles between these dates, and must therefore be a very close approximation; for if these showers did not mark the precise termination of the cycles, the resulting error would be divided by twenty-eight. Professor Newton showed that this value of the cycle required that the number of revolutions performed by the meteoroids in one year should be either $2 \pm \frac{1}{33.25}$ or $1 \pm \frac{1}{33.25}$ or $\frac{1}{33.25}$. In other words, the periodic time of the meteoroids must be either 180.0 or 185.4 or 354.6 or 376.6 days, or 33.25 years. Now, the velocity of any body in the solar system has a simple relation to its periodic time and its distance from the sun. Assuming, therefore, any one of these five values of the periodic time, we have the velocities of the Leonids at the node very sharply determined. From this velocity, with the position of the apparent radiant, which gives the direction of the relative motion, and with the knowledge that the heliocentric motion is retrograde, we may easily determine the orbit.

We have therefore five orbits from which to choose. The calculation of the secular motion of the node, due to the disturbing action of the planets, would enable us to decide between these orbits.*

* Amer. Jour. Sci. (2), vol. xxxvii, p. 377, and vol. xxxviii, p. 53.

Such are the most important conclusions which Professor Newton derived from the study of these remarkable showers, interesting not only from the magnificence of the spectacle occasionally exhibited, but in a much higher degree from the peculiarity in the periodic character of their occurrence, which affords the means of the determination of the orbit of the meteoroids with a precision which would at first sight seem impossible.

Professor Newton anticipated a return of the shower in 1866, with some precursors in the years immediately preceding—a prediction which was amply verified. In the meantime he turned his attention to those average values which relate to large numbers of meteors not belonging to any particular swarm.

This kind of investigation Maxwell has called *statistical*, and has in more than one passage signalized its difficulties. The writer recollects a passage of Maxwell which was pointed out to him by Professor Newton, in which the author says that serious mistakes have been made in such inquiries by men whose competency in other branches of mathematics was unquestioned. Doubtless Professor Newton was very conscious of the necessity of caution in those inquiries, as is indeed abundantly evident from the manner in which he expressed his conclusions; but the writer is not aware of any passage in which Professor Newton has afforded an illustration of Maxwell's remark.

The results of those investigations appeared in an elaborate memoir "On shooting stars," which was read to the National Academy in 1864, and appeared two years later in the Memoirs.* An abstract was published in the American Journal of Science in 1865.† The following are some of the subjects treated, with some of the more interesting results:

The distribution of the apparent paths of shooting stars in azimuth and altitude.

The vertical distribution of the luminous part of the real paths. The value found for the mean height of the middle point of the luminous path was a trifle less than sixty miles.

The mean length of apparent paths.

The mean distance of paths from the observer.

The mean foreshortening of paths.

* Vol. i, 3d memoir.

† Amer. Jour. Sci. (2), vol. xxxix, p. 193.

The mean length of the visible part of the real paths.

The mean time of flight as estimated by observers.

The distribution of the orbits of meteoroids in the solar system.

The daily number of shooting stars, and the density of the meteoroids in the space which the earth traverses. The average number of shooting stars which enter the atmosphere daily and which are large enough to be visible to the naked eye, if the sun, moon, and clouds would permit, is more than seven and a half millions. Certain observations with instruments seem to indicate that this number should be increased to more than four hundred millions to include telescopic shooting stars, and there is no reason to doubt that an increase of optical power beyond that employed in these observations would reveal still larger numbers of these small bodies. In each volume of the size of the earth there are as many as thirteen thousand small bodies, each of which is such as would furnish a shooting star visible under favorable circumstances to the naked eye.

These conclusions are certainly of a startling character, but not of greater interest than those relating to the velocity of meteoroids. There are two velocities to be considered, which are evidently connected—the velocity relative to the earth and the velocity of the meteoroids in the solar system. To the latter great interest attaches from the fact that it determines the nature of the orbit of the meteoroids. A velocity equal to that of the earth indicates an orbit like that of the earth; a velocity $\sqrt{2}$ times as great, a parabolic orbit like that of most comets, while a velocity greater than this indicates a hyperbolic orbit.

Professor Newton sought to form an estimate of this critical quantity in more than one way. That on which he placed most reliance was based on a comparison of the numbers of shooting stars seen in the different hours of the night. It is evident that in the morning, when we are in front of the earth in its motion about the sun, we should see more shooting stars than in the evening, when we are behind the earth; but the greater the velocity of the meteoroids compared with that of the earth, the less the difference would be in the numbers of evening and morning meteors. After a careful discussion of the evidence Professor Newton reached the conclusion that "we may regard as almost certain (on the hypothesis of an equable distribution of the directions of absolute motions) that the mean velocity of the meteoroids exceeds considerably that of the earth; that the orbits are not approximately circular, but resemble more the orbits of comets."

This last sentence, which is taken from the abstract published in 1865, and is a little more definitely and positively expressed than the corresponding passage in the original memoir, indicating apparently that the author's conviction had been growing more positive in the interval, or at least that the importance of the conclusion had been growing upon him, embodies what is perhaps the most important result of the memoir, and derives a curious significance from the discoveries which were to astonish astronomers in the immediate future.

The return of the November or Leonid shower in 1865, and especially in 1866, when the display was very brilliant in Europe, gave an immense stimulus to meteoric study and an especial prominence to this stream of meteoroids. "Not since the year 1759," says Schiaparelli, "when the predicted return of a comet first took place, had the verified prediction of a periodic phenomenon made a greater impression than the magnificent spectacle of November, 1866. The study of cosmic meteors gained thereby the dignity of a science, and took finally an honorable place among the other branches of astronomy."*

Professor J. C. Adams then took up the calculation of the perturbations determining the motion of the node of the Leonids. We have seen that Professor Newton had shown that their periodic time was limited to five sharply determined values, each of which, with the other data, would give an orbit, and that the true orbit could be distinguished from the others by the calculation of the secular motion of the node. Professor Adams first calculated the motion of the node due to the attractions of Jupiter, Venus, and the Earth for the orbit having a period of 354.6 days. This amounted to a little less than 12′ in 33.25 years. As Professor Newton had shown that the dates of the showers require a motion of 29′ in 33.25 years, the period of 354.6 days must be rejected. The case would be nearly the same with a period of 374.6 days, while a period of 180 or 185.4 days would give a still

* Schiaparelli: Entwurf einer astronomischen Theorie der Sternschnuppen, p. 55.

smaller motion of the node. Hence, of the five possible values indicated by Professor Newton, four were shown to be entirely incompatible with the motion of the node, and it only remained to examine whether the fifth period, viz., 33.25 years, would give a motion of the node in accordance with the observed value. As this period gives a very long ellipse for the orbit, extending a little beyond the orbit of Uranus, it was necessary to take account of the perturbations due to that planet and to Saturn. Professor Adams found 28′ for the motion of the node. As this value must be regarded as sensibly identical with Professor Newton's 29′ of observed motion, no doubt was left in regard to the period of revolution or the orbit of the meteoroids.*

About this time M. Schiaparelli was led by a course of reasoning similar to Professor Newton's to the same conclusion—that the mean velocity of the meteoroids is not very different from that due to parabolic orbits. In the course of his speculations in regard to the manner in which such bodies might enter the solar system the questions suggested themselves: whether meteoroids and comets may not have a similar origin; whether in case a stream of meteoroids should include a body of sufficient size this would not appear as a comet; and whether some of the known comets may not belong to streams of meteoroids. Calculating the orbit of the Perseids from the radiant point, with the assumption of a nearly parabolic orbit, he found elements very similar to those of the great comet of 1862, which may therefore be considered as one of the Perseids, probably the largest of them all.† At that time no known cometic orbit agreed in its elements with that of the Leonids, but a few months later, as soon as the definitive elements of the orbit of the first comet of 1866 were published, its resemblance to that of the Leonids, as calculated for the period of 33.25 years, which had been proved to be the correct value, was strikingly manifested, attracting at once the notice of several astronomers.

Other relations of the same kind have been discovered later, of which that of Biela's comet and the meteors of early December and late November, sometimes called Andromeds, is the most interesting, as we have seen the comet breaking up under

* Monthly Notices Roy. Astr. Soc., vol. xxvii, p. 247.

† Schiaparelli: Entwurf einer astronomischen Theorie der Sternschnuppen, pp. 49–54.

the influence of the sun; but in no case is the coincidence so striking as in that of the Leonids, since in no other case is the orbit of the meteoroids completely known independently of that of the comet and without any doubtful or arbitrary assumption in regard to their periodic time.

The first comet of 1866 is probably not the only one belonging to the Leonid stream of meteoroids. Professor Newton has remarked that the Chinese annals mention two comets which passed rapidly in succession across the sky in 1366, a few days after the passage of the Earth through the node of the Leonid stream, which was marked in Europe by one of the most remarkable star showers on record. The course of these comets, as described by the annalists, was in the line of the Leonid stream.*

This identification of comets with meteors or shooting stars marks an epoch in the study of the latter. Henceforth they must be studied in connection with comets. It was presumably this discovery which led Professor Newton to those statistical investigations respecting comets which we shall presently consider. At this point, however, at the close, as it were, of the first chapter in the history of meteoric science, it seems not unfitting to quote the words of an eminent foreign astronomer, written about this time, in regard to Professor Newton's contributions to this subject. In an elaborate memoir on shooting stars in the *Comptes Rendus** M. Faye says, with reference to our knowledge of these bodies and their orbits in the solar system, "We may find in the works of M. Newton, of the United States, the most advanced expression of the state of science on this subject, and even the germ, I think, of the very remarkable ideas brought forward in these last days by M. Schiaparelli and M. Le Verrier."†

The first fruit of Professor Newton's statistical studies on comets appeared in 1878 in a paper "On the origin of comets."‡ In this paper he considers the distribution in the solar system of the known cometic orbits, and compares it with what we might expect on either of two hypotheses—that of Kant, that the comets were formed in the evolution of the solar system from the more distant portion of the solar nebula, and that of Laplace, that the

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*Amer. Jour. Sci., (2), vol. xliii, p. 298, and vol. xlv, p. 91; or Encyc. Britann., Article "Meteor."

†Comptes Rendus, T. lxiv (1867), p. 550.

‡Amer. Jour. Sci. (3), vol. xvi, p. 165.

comets have come from the stellar spaces, and in their origin had no relation to the solar system.

In regard to the distribution of the aphelia, he shows that, except so far as modified by the perturbations due to the planets, the theory of internal origin would require all the aphelia to be in the vicinity of the ecliptic, while the theory of external origin would make all directions of the aphelia equally probable, which would give a distribution of the aphelia in latitude in which the frequency is as the cosine of the latitude. The actual distribution comes very near to this, but as the effect of perturbations would tend to equalize the distribution of aphelia in all directions, Professor Newton does not regard this argument as entirely decisive. He remarks, however, that if Kant's hypothesis be true, the comets must have been revolving in their orbits a very long time, and the process of the disintegration of comets must be very slow.

In regard to the distribution of the orbits in inclination, Professor Newton shows that the theory of internal origin would make all inclinations equally probable; the theory of external origin would make all directions of the normal to the plane of the orbit equally probable. On the first hypothesis, therefore, we should expect a uniform distribution in inclination; on the second, a frequency proportional to the sine of the inclination. It was shown by a diagram, in which the actual and the two theoretical distributions are represented graphically, that the actual distribution agrees pretty well with the theory of external origin, and not at all with that of internal origin. It was also shown that the curve of actual distribution cannot be made to agree with Kant's hypothesis by any simple and reasonable allowances for the effect of perturbations. On the other hand, if we assume the external origin of comets, and ask how the curve of sines must be modified in order to take account of perturbations, it is shown that the principal effect will be to increase somewhat the number of inclinations between 90° and 135° at the expense of those between 45° and 90°. It is apparent at once from the diagram that a change of this kind would make a very good agreement between the actual and theoretical curves, the only important difference remaining being due to comets of short periods, which mostly have small inclinations with direct motion. These should not weigh very much, Professor Newton observes, in the general question of the distribution of inclinations, because they return so frequently and are so easily detected that their number in a list of observed comets is out of all proportion to their number among existing comets.

But this group of comets of short periods can be readily explained on the theory of an external origin. For such comets must have lost a large part of their velocity by the influence of a planet. This is only likely to happen when the comet overtakes the planet and passes in front of it. This implies that its original motion was direct and in an orbit of small inclination to that of the planet, and although it may lose a large part of its velocity, its motion will generally remain direct and in a plane of small inclination. This very interesting case of the comets of short periods and small inclinations, which was treated rather briefly in this paper, was discussed more fully by Professor Newton at the meeting of the British Association in the following year.*

Many years later Professor Newton returned to the same general subject in a very interesting memoir "On the Capture of Comets by Planets, especially their Capture by Jupiter," which was read before the National Academy in 1891, and appeared in the Memoirs of the Academy two years later.† This contains the results of careful statistical calculations on the effect of perturbations on orbits of comets originally parabolic. It corroborates the more general statements of the earlier paper, giving them a precise quantitative form. One or two quotations will give some idea of the nature of this very elaborate and curious memoir, in which, however, the results were largely presented in the form of diagrams.

On a certain hypothesis regarding an original equable distribution of comets in parabolic orbits about the sun, it is shown that "if in a given period of time a thousand million comets come in parabolic orbits nearer to the sun than Jupiter, 126 of them will have their orbits changed" by the action of that planet "into ellipses with periodic times less than one-half that of Jupiter; 839 of them will have their orbits changed into ellipses with periodic times less than that of Jupiter; 1,701 of them will have

* Report Brit. Assoc. Adv. Sci. for 1879, p. 272.

† See Mem. Nat. Acad. Sci., vol. vi, 1st memoir, or Amer. Journ. Sci. (3), vol. xlii, pp. 183 and 482.

their orbits changed into ellipses with periodic times less than one and a half times that of Jupiter, and 2,670 of them will have their orbits changed into ellipses with periodic times less than twice that of Jupiter." A little later Professor Newton considers the question, which he regards as perhaps more important, of the direct or retrograde motion of the comets after such perturbations. It is shown that of the 839 comets which have periodic times less than that of Jupiter, 203 will have retrograde motions and 636 will have direct motions; also, that of the 203 with retrograde motion and of the 636 with direct motion, 51 and 257 respectively will have orbits inclined less than 30 degrees to that of Jupiter.

We have seen that the earliest of Professor Newton's more important studies on meteors related to the Leonids, which at that time surpassed all other streams in interest. One of his later studies related to another stream, which had in the meantime acquired great importance. The identification of the orbit of the December meteors with that of Biela's comet, which we have already mentioned, gave these bodies an unique interest, as the comet had been seen to break up under the influence of the sun. Here the evolution of meteoroids was taking place before our eyes; and this interest was heightened by the showers of 1872 and 1885, which in Europe seem to have been unsurpassed in brilliancy by any which have occurred in this century.*

The phenomena of each of these showers were carefully discussed by Professor Newton. Among the principal results of his paper on the later shower are the following: †

The time of maximum frequency of meteors was 1885, November 27, 6h. 15m. Gr. m. t. The estimated number per hour visible at one place was then 75,000. This gives a density of the meteoroids in space represented by one to a cube of twenty miles edge. The really dense portion of the stream through

* It is a curious coincidence that the original discoverer of the December shower as a periodic phenomenon, Mr. Edward C. Herrick, should have been (with a companion) the first to observe that breaking up of the parent body which was destined to reinforce the meteoric stream in so remarkable a manner. See Professor Newton's lecture, "The Story of Biela's Comet," Amer. Jour. Sci. (3), vol. xxxi, pp. 85 and 88.

† Amer. Jour. Sci. vol. (3), xxxi, p. 409.

which we passed was less than 100,000 miles in thickness, and nearly all would be included in a thickness of 200,000 miles.

A formula is given to express the effect of the earth's attraction on the approaching meteoroids in altering the position of the radiant. This is technically known as the zenithal attraction, and is quite important in the case of those meteors on account of their small relative velocity. The signification of the formula may be roughly expressed by saying that the earth's attraction changes the radiant of the Biela meteors toward the vertical of the observer one-tenth of the observed zenith distance of the radiant, or, more briefly, the zenithal attraction is for these meteors one-tenth of the observed zenith distance. The radiant, even after this correction and another for the rotation of the earth on its axis, was not a point, but an area of several degrees diameter. The same has been observed in regard to other showers, but the result comes out more distinctly in the present case, because the meteors were so numerous and the shower so well observed.

This implies a want of parallelism in the paths of the meteors, and it is a very important question whether it exists before the meteors enter our atmosphere, or whether it is due to the action of the atmosphere.

Professor Newton shows that it is difficult to account for so large a difference in the original motions of the meteoroids, and thinks it reasonable to attribute a large part of the want of parallelism to the action of the atmosphere on bodies of an irregular form, such as we have every reason to believe that the meteoroids have when they enter our atmosphere. The effect of the heat generated will be to round off the edges and prominent parts, and to reduce the meteor to a form more and more spherical. It is therefore quite natural that the greater portion of the curvature of the paths should be in the invisible portion, and thus escape our notice. It is only in exceptional cases that the visible path is notably curved.

But the great interest of the paper centers in the discussion of the relation of this shower to preceding showers and to Biela's comet. The changes in the date of the shower (from December 6 to November 27) and in the position of the radiant are shown to be related to the great perturbations of Biela's comet in 1794 1831, and 1841–'42. The showers observed by Brandes, Decem ber 6, 1798, by Herrick, December 7, 1838, and by Heis, December 8 and 10, 1847, are related to the orbit of Biela's comet, as it was in 1772; while the great showers of 1872 and 1885, as well as a trifling display in 1867, are related to the orbit of 1852.

Assuming, then, that the meteoroids which we met on the 27th of November, 1872, did not leave the immediate vicinity of the Biela comet before 1841, we seem to have the data for a very precise determination of their orbit between those dates. The same is true of those which we met in 1885. The computation of these orbits, the author remarks, may possibly give evidence for or against the existence of a resisting medium in the solar system.

In his last public utterance on the subject of meteors, which was on the occasion of the recent sesquicentennial celebration of the American Philosophical Society, Professor Newton returns to the subject of the Biela meteoroids, and finds in the scattering which they show in the plane of their orbit a proof of a disturbing force in that plane, and therefore not due to the planets. The force exerted by the sun appears to be modified somewhat as we see it in the comets' tails, where, indeed, the attraction is changed into repulsion. Something of the same sort, on a smaller scale relatively to the mass of the bodies, appears to modify the sun's action on the meteoroids.*

In 1888 Professor Newton read before the National Academy a very interesting paper "Upon the relation which the former orbits of those meteorites that are in our collections and that were seen to fall had to the earth's orbit." † This was based upon a very careful study of 116 cases in which there are statements indicating more or less definitely the direction of the motion, as well as 94 more in which only the time of the fall is known. The following conclusions were reached:

1. The meteorites which we have in our cabinets and which were seen to fall were originally (as a class and with a very small number of exceptions) moving about the sun in orbits that had inclinations less than 90°; that is, their motions were direct, not retrograde.

2. The reason why we have only this class of stones in our collections is not one wholly or even mainly dependent on the

*Amer. Jour. Sci. (3), vol. xlvii, p. 152.

† Amer. Jour. Sci. (3), vol. xxxvi, p. 1.

habits of men, nor upon the times when men are out of doors, nor on the places where men live, nor on any other principle of selection acting at or after the arrival of the stones at the ground. Either the stones which are moving in the solar system across the earth's orbit move in general in direct orbits; or else for some reason the stones which move in retrograde orbits do not in general come through the air to the ground in solid form.

3. The perihelion distances of nearly all the orbits in which these stones moved were not less than 0.5 nor more than 1.0, the earth's radius vector being unity.

It was added that it seems a natural and proper corollary to these propositions (unless it shall appear that stones meeting the earth are destroyed in the air) that the larger meteorites moving in our solar system are allied much more closely with the group of comets of short period than with the comets whose orbits are nearly parabolic. All the known comets of shorter periods than 33 years move about the sun in direct orbits that have moderate inclinations to the ecliptic. On the contrary, of the nearly parabolic orbits which are known only a small proportion of the whole number have small inclinations with direct motion.

We have briefly mentioned those papers which seem to constitute the most important contributions to the science of meteors and comets. To fully appreciate Professor Newton's activity in this field, it would be necessary to take account of his minor contributions. These are given in the annexed bibliography, where it will be observed that more than half of the entries relate to these subjects. Most interesting and instructive to the general reader are his utterances on occasions when he has given a résumé of our knowledge on these subjects, or some branch of them, as in the address on "The meteorites, the meteors, and the shooting stars,"* which he delivered in 1886, as retiring president of the American Association for the Advancement of Science, or in certain lectures in the public courses of the Sheffield Scientific School of Yale University, entitled "The Story of Biela's Comet" (1874),† "The Relation of Meteorites to Comets" (1879), ‡ and "The Worship of Meteorites" (1889), § or in the articles on

* Proceedings Amer. Assoc. Adv. Sci., vol. xxxv, p. 1.

† Amer. Jour. Sci. (3), vol. xxxi, p. 81.

‡ Nature, vol. xix, pp. 315 and 340.

§ Amer. Jour. Sci. (4), vol. iii, p. 14.

"Meteors" in the Encyclopædia Britannica and in Johnson's Cyclopædia.

If we ask, what traits of mind and character are indicated by these papers, the answer is not difficult. Professor Klein has divided mathematical minds into three leading classes: the logicians, whose pleasure and power lie in subtlety of definition and dialectic skill; the geometers, whose power lies in the use of the space-intuitions, and the formalists, who seek to find an algorithm for every operation.* Professor Newton evidently belonged to the second of these classes, and his natural tastes seemed to find an equal gratification in the development of a system of abstract geometrical truths, and in the investigation of the concrete phenomena of nature as they exist in space and time. But these papers show more than the type of mind of the author; they give no uncertain testimony concerning the character of the man. In all these papers we see a love of honest work, an aversion to shams, a caution in the enunciation of conclusions. a distrust of rash generalizations and speculations based on uncertain premises. He was never anxious to add one more guess on doubtful matters in the hope of hitting the truth, or what might pass as such for a time, but was always ready to take infinite pains in the most careful testing of every theory. With these qualities was united a modesty which forbade the pushing of his own claims and desired no reputation except the unsought tribute of competent judges. At the close of the article on meteors in the Encyclopædia Britannica, in which there is not the slightest reference to himself as a contributor to the subject, he remarks: "Meteoric science is a structure built stone by stone by many builders." We may add that no one has done more than himself to establish the foundations of this science, and that the stones which he has laid are not likely to need relaying.

The value of Professor Newton's work has been recognized by learned societies and institutions, both at home and abroad. He received the honorary degree of Doctor of Laws from the University of Michigan in 1868. He was President of the Section of Mathematics and Astronomy in the American Association for the Advancement of Science in 1875, and President of

* Lectures on Mathematics (Evanston), p. 2.

the Association in 1885. On the first occasion he delivered an address entitled "A Plea for the Study of Pure Mathematics;" on the second, the address on Meteorites, etc., which we have already mentioned. Of the American Mathematical Society he was Vice-President at the time of his death. It is not necessary to remind members of this Academy that the first and as yet the only J. Lawrence Smith medal was awarded to Professor Newton in 1888 for his investigations on the orbits of meteoroids, but I may be permitted to recall a sentence or two from his brief reply to the President on that occasion: "To discover some new truth in nature," he said, "even if it concerns the small things in the world, gives one of the purest pleasures in human experience. It gives joy to tell others of the treasure found."

Besides the various learned societies in our own country of which he was a member, including the American Academy of Arts and Sciences from 1862, the National Academy of Sciences from its foundation in 1863, the American Philosophical Society from 1867, he was elected in 1872 Associate of the Royal Astronomical Society of London, in 1886 Foreign Honorary Fellow of the Royal Society of Edinburgh, and in 1892, Foreign Member of the Royal Society of London.

But the studies which have won for their author an honorable reputation among men of science of all countries form only one side of the life of the man whom we are considering. Another side, perhaps the most important, is that in which he was identified with the organic life of the College and University with which he was connected from a very early age. In fact, we might almost call the studies which we have been considering the recreations of a busy life of one whose serious occupation has been that of an instructor. If from all those who have come under his instruction we should seek to learn their personal recollections of Professor Newton, we should probably find that the most universal impression which he made on his classes was that of his enthusiastic love of the subject which he was teaching.

A department of the University in which he took an especial interest was the Observatory. This was placed under his direction at its organization in 1882, and although he subsequently resigned the nominal directorship, the institution remained virtually under his charge, and may be said to owe its existence in large measure to his untiring efforts and personal sacrifice in its behalf.

One direction of activity in the Observatory was suggested by a happy accident which Professor Newton has described in the American Journal of Science for September, 1893. An amateur astronomer in a neighboring town, Mr. John Lewis, accidentally obtained the track of a large meteor on a stellar photograph. He announced in the newspapers that he had secured such a photograph, and requested observations from those who had seen the meteor. The photographic plate and letters received from various observers were placed in Professor Newton's hands and were discussed in the paper referred to. The advantages of photographic observation were so conspicuous that Professor Newton was anxious that the observatory should employ this method of securing the tracks of meteors. With the aid of an appropriation granted by the National Academy from the income of the J. Lawrence Smith fund, a battery of cameras was mounted on an equatorial axis. By this means a number of meteor tracks have been obtained of the August meteors, and in one case, through a simultaneous observation by Mr. Lewis at Ansonia, Professor Newton was able to calculate the course of the meteor in the atmosphere with a probable error which he estimated at less than a mile. The results which may be expected at the now near return of the Leonids will be of especial interest, but it will be for others to utilize them.

Professor Newton was naturally much interested in the collection of meteorites, and the fine collection of stones and irons in the Peabody Museum of Yale University owes much to his efforts in this direction.

Professor Newton was a member of the American Metrological Society from its foundation, and was conspicuously active in the agitation which resulted in the enactment of the law of 1866 legalizing the use of the metric system. He prepared the table of the metric equivalents of the customary units of weights and measures which was incorporated in the act, and by which the relations of the fundamental units were defined. But he did not rest here. Appreciating the weakness of legislative enactment compared with popular sentiment, and feeling that the real battle was to be won in familiarizing the people with the metric system, he took pains to interest the makers of scales and rulers and other devices for measurement in adopting the units and graduations of the metric system, and to have the proper tables introduced into school arithmetics.

He was also an active member of the Connecticut Academy of Arts and Sciences, serving several years both as secretary and as president. He was from 1864 associate editor of the American Journal of Science, having especial charge of the department of astronomy. His notes on observations of meteors and on the progress of meteoric science, often very brief, sometimes more extended, but always well considered, are especially valuable.

In spite of his studious tastes and love of a quiet life, he did not shirk the duties of citizenship, serving a term as alderman in the city council, being elected, we may observe, in a ward of politics strongly opposed to his own.

Professor Newton married, April 14, 1859, Anna C., daughter of the Rev. Joseph C. Stiles, D. D., of Georgia, at one time pastor of the Mercer Street Presbyterian Church in New York City and subsequently of the South Church in New Haven. She survived her husband but three months, leaving two daughters.

In all these relations of life the subject of this sketch exhibited the same traits of character which are seen in his published papers—the same modesty, the same conscientiousness, the same devotion to high ideals. His life was the quiet life of the scholar, ennobled by the unselfish aims of the Christian gentleman; his memory will be cherished by many friends; and so long as astronomers, while they watch the return of the Leonids marking off the passage of the centuries, shall care to turn the earlier pages of this branch of astronomy, his name will have an honorable place in the history of the science.

PUBLISHED WRITINGS OF HUBERT A. NEWTON.

1853. On the Deviation of Falling Bodies to the South of a Perpendicular. *Astr. Jour.*, vol. 3, pp. 126, 133.

1857. On the Motion of the Gyroscope. *Amer. Jour. Sci.* (2), vol. 24, pp. 253–254.

1858. Prize Problem No. 5. *Math. Monthly*, vol. 1, p. 2.

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HUBERT ANSON NEWTON.

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[This list has been taken, for the most part, from "Bibliographies of the present Officers of Yale University," 1893.]

MEMOIR

OF

THOMAS LINCOLN CASEY.

1831-1896.

BY

HENRY L. ABBOT.

READ BEFORE THE NATIONAL ACADEMY, APRIL 21, 1897.

BIOGRAPHICAL MEMOIR OF THOMAS LINCOLN CASEY.

Mr. President and Gentlemen of the Academy:

Our late associate was born in garrison at Sacketts Harbor, New York, on May 10, 1831. His father, the late General Silas Casey, was then stationed at that post, and the boy's earliest associations were those surrounding a military life. His family trace their ancestry back to the early settlers of Rhode Island, and the old homestead near Newport still retains the bullet marks received in a skirmish during the war of the Revolution. With such antecedents it was but natural that a West Point education should be the object of his wishes, and an appointment at large was conferred by President Polk dating on July 1, 1848.

With fine natural abilities and stimulated to persevering exertions by ambition and by an appreciation of the influence of high standing at the Military Academy upon his future career, he at once took a prominent position in his class, and at the expiration of the four years' course was graduated at its head. In the Corps of Cadets his soldierly figure and military tastes and bearing won for him successively the appointments of first sergeant of his company in his second class year and of senior captain in his last year. Among his classmates who attained high rank and distinction in the civil war were: Generals H. W. Slocum, D. S. Stanley, G. L. Hartsuff, C. R. Woods, Alex. McD. McCook, Aug. V. Kautz, and George Crook.

On graduation Cadet Casey was assigned to the Corps of Engineers as brevet second lieutenant, and, passing successively through all intermediate grades, on July 6, 1888, he attained the highest, that of Brigadier General and Chief of Engineers. He was retired from active service on May 10, 1895, by operation of law; and died on March 25, 1896.

At the outset of his career, after serving for about two years as assistant engineer at Fort Delaware, Lieutenant Casey was transferred to West Point, where he remained, performing various academic duties, for about three years; he was then sent to the Pacific coast, where he commanded a detachment of engineer troops and performed other military services until the spring of 1861, when the gathering war clouds caused him to be ordered to the East. After serving on General Butler's staff at Fort Monroe for about two months he was placed in charge of constructing defensive works on the coast of Maine and on recruiting duty for the engineer troops in the field, taking station at Portland. Here he remained until November, 1867, when he was transferred to Washington as assistant in the office of General Humphreys, then Chief of Engineers. This city remained his permanent residence for the rest of his life, although he was absent for about two years, as president of the Board of Engineers, in New York in 1886–'88, and was sent to Europe in 1875 as a member of a board to study and report upon the condition of submarine mining for coast defense in Europe.

There are but few of the more modern public works in Washington and its vicinity which have not come under General Casey's skillful administration. He constructed the last two-thirds of the State, War, and Navy Department building, saving to the Government over two million dollars by improved methods; completed the Washington Monument; nearly completed the Congressional Library; had charge of the construction of the Medical Museum and Library; had much to do with the Washington Aqueduct; served on an important board to advise upon the ventilation of the House of Representatives, and was long a member of the Light-house Board. To all these duties he brought intelligence, energy, and professional skill of a high order. Congress on several occasions showed by special legislation its appreciation of his services in reducing expenses and judiciously directing the works committed to his charge.

During the seven years in which he was at the head of the Engineer Department of the Army, appropriations for works of river and harbor improvement were liberal and much progress was made, a good beginning was had in renovating our antiquated system of coast defense, and the administration of these public works was improved by grouping all the different engineer districts in charge of junior officers of the corps into five "divisions" and placing them under the systematic inspection and supervision of five of the colonels, designated Division Engineers.

This detail of administration was a distinct advance on the earlier practice, and is to be credited to the good judgment of General Casey.

From this brief outline of the public duties which engrossed the time and attention of our colleague it is evident that scant leisure remained for purely scientific investigation. He was interested in physical research, and his name appears among the signers of the original letter to Professor Henry requesting him to preside at a meeting called to organize what is now well known as the Washington Philosophical Society. He was elected a member of the National Academy of Sciences in 1890, and his presence will be missed at the annual meetings in Washington. He had in view the preparation of a paper on the motion of the center of gravity of the Washington Monument under the varying effects of temperature and wind, based on a long series of accurate observations conducted under his direction, but it was never completed. While his life work was so largely directed to architectural construction as to afford little scope for the solution of novel scientific problems, the bold and successful method he adopted for replacing the defective foundations of the Washington Monument won for him the cross of an officer in the Legion of Honor of France, conferred by the French government in recognition of professional merit; and perhaps a brief description of this achievement will be not out of place here.

The construction of the Washington Monument was begun in 1848 by the Washington National Monument Society, organized in September, 1833, after the failure of Congressional legislation, the intention being to depend upon voluntary contributions for the cost of erection. Economy became, therefore, a matter of more than usual importance in works of this character. Shortly after operations were begun doubts as to the sufficiency of the foundations appear to have been raised, for under date of January 18, 1853, Comptroller Whittlesey wrote to the president of the commission, "There were persons here who wanted to have the money on hand all buried beneath the surface, and as much more as might be contributed for some time. The building committee and the board of managers felt the responsibility of having a safe foundation, and believing that was obtained, they considered they were bound to the contributors to spend no money unnecessarily." At that date the structure had been raised 170 feet above the ground and no cracks had appeared. Operations were suspended from lack of funds in 1856, the total height above ground being 174 feet.

Nearly a quarter of a century passed before work was resumed under a Congressional appropriation, and as no useful records had been preserved to indicate details of construction, grave doubts were entertained as to the character of the early work. A select committee was appointed by the House of Representatives in 1873, and its first step was to call for an examination of the security of the foundations. The necessary borings and excavations were made and efforts to detect what, if any, settlement had occurred were skillfully conducted with the following results:

The foundation course rested at a depth of 8 feet below the surface on a compressible bed consisting of a mixture of clay and fine sand, the former in excess, but decreasing with the depth in the following proportions, the figures indicating the excess of clay over voids, the plane of reference being that of the bottom bed:

Depth.	West side.	East side.	North side.	South side.
2 feet.....	68 per cent.	68.5 per cent.	70 per cent.	61 per cent.
7 feet....	51 per cent.	45.2 per cent.	46 per cent.	46.7 per cent.
12 feet.....	31.5 per cent.	....	43.8 per cent.	33.8 per cent.
14 feet.....	19.7 per cent.	....	17 per cent	....
15 feet.....	....	18.5 per cent.	....	....
16 feet.....	....	11 per cent.	5 per cent.	13.3 per cent.

Water was reached at about 13 feet. Below that level a stratum of gravel and sand was encountered containing a less proportion of clay and changing gradually at a depth of 15 or 16 feet into a mixture of clay, sand, gravel, pebbles, and bowlders, forming a hard-pan of good resistance.

The masonry foundation at the bottom course was 80 feet square, and at the top course 59 feet square, rising between these planes to a height of about 24 feet, of which 8 feet were below and 16 feet were above the surface of the ground. The mass consisted of rubble masonry of inferior quality, the rock being gneiss of random dimensions, with approximately rectangular faces about 3 feet in height, roughly laid, with probably an excess of moderately pure lime mortar, having spalls embedded therein.

The projected shaft was of bluestone rubble masonry faced with white marble. Its height was to be 600 feet above the foundation, with a breadth at base of 55 feet and at top of 30 feet, having an interior well 25 feet square to accommodate a stairway. Its weight, including that of the foundations, was estimated at a little over 70,000 tons, giving, with no allowance for wind pressure, a dead load of about 11 tons per square foot of bed. The height above ground being already 174 feet, accurate measurements demonstrated that the top inclined 1.6 inches toward the north and west, with a corresponding dip in the upper surface of the lower course of marble.

The old records afforded no means of determining the amount of subsidence due to the weight of the actual construction. Although tests made at an early day had shown that the stone possessed ample strength to support the weight, the faulty method of laying had caused a few cracks in the courses near the base of the shaft, together with chipping and fracturing at the lower joints.

These results demonstrated that the doubts as to the stability of the monument were well founded. The matter was referred to two boards of distinguished engineers. The first reported: "The result of our investigations is that five tons is an excessive pressure for soils composed of clay and sand. We could not, therefore, with the information before us, recommend that any *additional* pressure should be thrown on the site of the Washington monument." The pressure of the incomplete structure as then built was estimated at five tons per square foot. The second board reported "that the stratum of sand and clay upon which the monument rests is already loaded to the limit of prudence, if not indeed to the limit of safety, and that it does not offer sufficient resistance to compression to justify the completion of the shaft in accordance with the modified design (400 feet high) or any other design that will load the underlying soil beyond 10,000 pounds per square foot."

In a supplementary report, dated June 13, 1877, the second board reported that it deemed it practicable to give additional spread to the foundations of the monument, and to carry them down to the underlying gravel bed "either by replacing with solid masonry" (Portland cement and sharp sand) "the bed of compressible clay and sand which underlies the base of the monument or by circumscribing it with a wall possessing sufficient depth and stability to resist for an indefinite time any lateral movement of the soil under such additional load as may be placed upon the structure," and proceeded to set forth in detail the two methods suggested, giving preference to the latter.

Five years had now passed in discussions, not always free from acrimony, concerning the stability of the projected monument. In August, 1876, Congress had created a joint commission to direct and supervise the construction, and had provided funds which, however, were only to become available when the foundations had been decided to be sufficient. Authority to strengthen those existing was granted on June 14, 1878, and shortly after Lieutenant Colonel Casey was ordered to report to the joint commission as engineer in charge of the construction. He promptly prepared a project for strengthening the existing foundations sufficiently to permit the obelisk to be carried to the desired height, this project necessarily defining the form and dimensions of the finished monument. These plans were approved on October 1, 1878, and active operations were at once begun.

The project for the new foundations, as briefly stated by Colonel Casey at the dedication of the monument, in 1885, "contemplated, first, the digging away of the earth from around and beneath the outer portions of the old foundation and replacing it with Portland cement concrete masonry; then in removing a portion of the old masonry foundation itself from beneath the walls of the shaft and substituting therefor a continuous Portland cement enlargement extending out over the new subfoundation." This work was completed in May, 1880, at a cost of a little over $94,000. "As completed, the new foundation covers two and a half times as much area and extends 13.5 feet deeper than the old one. Indeed, the bottom of the new work is only two feet above the level of high tides in the Potomac, while the water which permeates the earth of the Monument lot stands six inches above this bottom. The foundation now rests upon a bed of fine sand some two feet in thickness, and this sand stratum rests upon a bed of boulders and gravel. Borings have been made in this gravel deposit for a depth of over 18 feet without passing through it, and so uniform is the character of the material upon which the foundation rests that the settlements of the several corners of the shaft have differed from each other by only the smallest subdivisions of an inch." The pressure on the soil underlying the structure nowhere exceeds nine tons per square foot, and is less than three tons near the outer edge of the foundation.

The substitution of new foundations for what have been shown to be insufficient under existing structures was at that date by no means a novelty to engineers, but never before had the delicate operation been undertaken on a work of this magnitude. Little by little fifty-one per cent. of the original bulk of the old mass was removed and forty-eight per cent. of the area of the base of the shaft was undermined. The effect of the successive excavations and underpinning on the huge column above, weighing over 32,000 tons, was scrutinized with all the precision known to modern science. Any apparent tendency to deflection from the vertical was at once checked by undermining on the opposite side, and thus the mass was swayed at pleasure, until at the end the original slight deviation was materially corrected.

The necessity of reducing weight to the minimum gave rise to many difficult problems in the construction of the shaft itself, notably in that of the pyramidion, but they were all successfully met as they arose. The work was done under the fire of ill-natured criticism on the part of the newspapers, which clearly indicated the storm of opprobrium which would burst upon the heads of the joint commission and its engineer had any part of their plans failed to meet public expectation. No little firmness and decision were needed under such conditions, and Colonel Casey showed himself to be the man for the occasion. He made no response to the attacks, but quietly pushed forward the work, and when the scaffolding was removed from the completed monument in February, 1885, and the beautiful shaft, 555 feet in height, stood revealed, universal admiration silenced all detractors. Much of the charming grace of the obelisk must be credited to a change in the early plans, due to Colonel Casey himself, who replaced the too flat apex by a pyramidion 55 feet in height, which, compared with the proportions of the shaft itself, conforms precisely to the lines exhibited in ancient Egyptian practice.

On August 31, 1886, the city was visited by a sharp earthquake shock, but no ill effects upon the masonry or on the level of the base could be detected. The structure was twice struck by lightning in 1885, with no serious injury, but additional protective devices have since been added which have proved effective. The monument stands, a simple shaft of pure white marble, perfect in architectural design and worthy in sunshine and in storm to commemorate the character of Washington.

General Casey was a man of marked individuality and of indefatigable industry, giving the closest attention to whatever came under his personal responsibility. He showed good judgment in selecting his assistants, and was quick to appreciate their merit. If in his official relations at the War Department the *fortiter in re* was sometimes more conspicuous than the *suaviter in modo*, in his home and among friends he was cordial and sympathetic. He was well versed in the early colonial history of this country and took special interest in genealogical researches, being a member of the New England Historic Genealogical Society and a frequent contributor to genealogical publications. He was at one time a director in the American Society of Civil Engineers.

In early life General Casey married Miss Emma Weir, daughter of Professor Robert W. Weir, of the U. S. Military Academy, and she and two sons survive him. He died, as he would have wished, in harness, the fatal summons coming as he was proceeding to the Congressional Library to attend to his duties as the engineer in charge of its construction.

MEMOIR

OF

GEORGE HAMMELL COOK.

1818-1889.

BY

G. K. GILBERT.

READ BEFORE THE NATIONAL ACADEMY, APRIL 21, 1897.

BIOGRAPHICAL MEMOIR OF GEORGE HAMMELL COOK.

GEORGE HAMMELL COOK was born at Hanover, New Jersey, on the 5th of January, 1818. He died in New Brunswick, New Jersey, September 22, 1889.

His ancestors on the male side came from England to Massachusetts in 1640, but for several generations have lived in New Jersey. He was the third son of John Cook and his wife Sarah Munn.*

His schooling was in the country school of his native town and in the Rensselaer Polytechnic Institute at Troy, New York, where he graduated at the age of 21. As a boy he assisted on two surveys for railways, and the degree he received at Troy was that of civil engineer. This early bent toward engineering was modified at Troy by association with Amos Eaton, from whom he acquired that interest in geology and other departments of natural history which determined his future career. After graduation he was employed in the Institute as tutor, then as adjunct professor, and finally as senior professor.

In 1846 he was married to Mary Halsey Thomas, who survives him. From 1846 to 1848 he engaged in business in Albany.

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* This statement is taken verbatim from a memoir of Professor Cook by James Neilson. Marks of quotation are omitted because consistency would demand their use with a very large number of parts of sentences. Writing seven years after Professor Cook's death, I find this historical part of my subject already compiled in nearly a dozen biographies and biographic notices, and these have been drawn on with the utmost freedom. I am especially indebted to the following:

Addresses commemorative of George Hammell Cook, Ph. D., LL. D., Professor of Geology and Agriculture in Rutgers College, delivered before the Trustees, Faculty, Students, and Friends of the College, June 17, 1890, Newark, 1891. [These addresses are by James Neilson, Abram S. Hewitt, J. W. Powell, J. B. Drury, and T. S. Doolittle. The same volume contains letters by James D. Dana and R. W. Raymond.]

George H. Cook, late State Geologist of New Jersey, by John C. Smock, *American Geologist*, December, 1889.

Obituary, George H. Cook, *Amer. Jour. Sci.*, vol. 38, 1889, pp. 498–499.

He then joined the teaching force of the Albany Academy, and was its principal from 1851 to 1853. In 1852 he was sent to Europe by the State of New York to study salt manufacture in the interest of the salt industry of Onondaga county; and the earliest of his scientific writings which I have discovered are reports to the State on methods of brine reduction and their chemistry. In 1853 he returned to his native State, being called to the chair of chemistry and natural sciences in Rutgers College, at New Brunswick. This chair he retained, under various titles, until his death, 36 years later, and it was during this period that the great work of his life was accomplished.

Properly to characterize Cook's scientific work it is necessary to recognize certain distinctions. Scientific research, or the seeking and discovery of the laws of nature, is sometimes carried on for its own sake or without reference to a definite ulterior end, and is then called *pure science.* The knowledge acquired through research is the foundation of human progress, but is thus utilized only through the discovery of methods of application, and the discovery of such methods constitutes *applied science.* These two are complementary, but they do not include all the work of science. There is also research which is prosecuted for the sake of, and with constant reference to, definite utilitarian ends, so that the discovery and the application of natural laws are parts of one process. This may be called *practical science.* The love of pure science is the blind instinct of civilization. It delights to lay eggs—the more, the better—but gives no thought nor care to their hatching. Applied science is a working bee who builds cells of utility, and in them rears to maturity the larvæ hatched from her sister's eggs. Practical science may rather be compared to intelligent parentage, which not only conceives and bears, but nourishes and rears its progeny, foreseeing the end from the beginning. Cook contributed little to pure science. He gave more to applied science. He devoted his life to practical science. A study of his work shows that every research was for a practical end, and that end was steadily kept in view. His methods of investigation were those of pure science, but he never suffered himself to be diverted from his chosen path to the search for natural knowledge which promised no immediate nor early tribute to the material needs of man.

The field of his labor was the State of New Jersey, and those who reaped the benefit were the citizens of New Jersey. His success was great. The talent and energy he brought to his work might have achieved world-wide fame in the domain of pure science. In the domain of applied science they would have given him great wealth. Used as they were, they brought him the sincerest appreciation, respect, and gratitude of the community for which he toiled.

The three subjects which most occupied him were geology, agriculture, and water supply, and, though their lines of research ran side by side and were partly interwoven, it is convenient to describe them separately.

In 1854, a year after Cook's return to New Jersey, a State geological survey was organized with Dr. William Kitchell at its head. Cook was his associate, with the title of assistant State geologist, and was actively engaged in the work until 1856, when the survey was suspended. In 1864 it was revived, and the legislative act providing for its maintenance named Cook as State geologist. This personal designation was repeated in subsequent acts, and he held the office continuously for a quarter of a century—until his death. The work of geologic surveying pursued the usual course, beginning with reconnoissance, following with the discrimination and mapping of formations in an approximate way, and afterward refining the classification, maps, and measurements; but the refinement was practically restricted to such details as were needed for the best understanding of recognized economic materials. The relations of the iron and zinc ores to the structure of the surrounding rocks were worked out. The sources of building stones, flagging, paving blocks, and other structural materials were described. The clays available for building brick, fire-brick, pottery, and porcelain were elaborately studied, and the reports on them gave powerful impetus to industries that have now reached great magnitude. Much attention was given to greensand and other mineral fertilizers; their extent was determined and the farming community was made acquainted with their existence and value. From all this work, involving a literary output of several thousand pages, but two results in pure science were deemed of such general interest as to demand publication outside the State. One was the determination of the southern boundary of the glacial drift, a pioneer contribution to the mapping of the chief terminal moraine; the other the demonstration and measurement of the secular sinking of the New Jersey coastal plain.

For the needs of the geologists, a topographic map had been begun under the direction of Dr. Kitchell, and this work was continued by his successor. Foreseeing the multifarious uses and great value of good maps, he established a high standard of excellence, and his State is today almost without a rival in the quality of its topographic delineation.

From the study of soils and mineral fertilizers to the study of broader agricultural questions was an easy step, and Cook soon became as deeply interested in problems of tillage as in mineral resources. It was largely through his influence that the administration of the land grant from the United States to the State of New Jersey for the promotion of agriculture and the mechanic arts was given to Rutgers College, and when the resulting scientific school was organized he was placed in charge of its agricultural branch. This was in 1864, and almost immediately he secured the purchase of a tract of 100 acres, which was called the "Experimental farm," and on which he instituted a series of experiments on the comparative value of various fertilizers and on kindred problems. Here, again, he was a pioneer, for it was not until eleven years later, 1875, that the Connecticut agricultural experiment station was founded. In 1870 he visited Europe for the purpose of studying the experimental work there in progress, and another tour of the European stations was made in 1878, while he was a delegate to the geological congress in Paris. He then undertook to enlarge the scope of his experimental work by securing State aid, and in 1880 succeeded. An agricultural experiment station was established and he became director. He was prominent also in the agitation which led to the passage by Congress in 1887 of the so-called Hatch bill, creating a national system of stations. His directorship of the State work continued for nine years—until his death.

In 1871 the New Jersey State Board of Agriculture was instituted, and Cook was so largely instrumental in procuring the necessary legislation that he is known as the founder of the board. During the remainder of his life he was a member of the board and its executive committee.

It is not necessary to recite the various researches he conducted or directed in and through these various organizations. Suffice it to say that he used scientific method for practical results; that he enlisted farmers' clubs and farmers in experimentation; that he made many annual tours among them, giving one or more lectures in each county, and that his results were published as rapidly as reached and widely utilized. In an age of general progress it is impossible to discriminate the product of one man's effort, but there can be no exaggeration in saying that the phenomenal development of the agriculture of his State was due to him more than to any other individual.

During the progress of the geological survey the subject of municipal water supply demanded public attention, and one of the important results of the topographic work was the delineation of the catchment basins, with their areas and altitudes. To this were added a preliminary study of forests as conservators of water, and eventually a system of rainfall records. As early as 1857 Cook began regular observations of temperature and rainfall at New Brunswick, and these were continued until his death, much of the actual work being done by him personally. At his suggestion volunteer observers started similar series of observations in various parts of the State, and in 1886 a State weather service was established under his direction. The publications of this organization consist merely of monthly records of local weather, a dry tabulation of facts, but I am informed by the Chief of the United States Weather Bureau that "some of the most valuable suggestions for the prosecution of State weather service work were made by Professor Cook, and the ideas originating with him have been largely followed in organization in other States."

In the investigation of surface waters Cook's function was largely that of an organizer, and the results belong chiefly to the future, but the search for artesian water, instituted by his advice and conducted to a large extent under his guidance, had before his death yielded the most gratifying returns. Through a long line of seaboard towns the contaminated and dangerous waters of surface wells have been replaced by pure waters drawn from deep-lying sands, and all the towns of the coastal plain are profiting by the new knowledge.

Cook had a strong constitution and what has been called a "genius for work." His labors were carried far into the night and resumed early in the morning, and much of his remarkable accomplishment must be credited to his untiring industry. Despite his multifarious responsibilities, he was at home to every visitor, and responded with unfailing patience to all calls for information. Through this freedom of intercourse he kept himself in touch with the people of the State, who were thus enabled to appreciate his earnestness and unselfishness, and this practice had much to do with the general confidence in him and his work which secured from successive legislatures votes that were nearly unanimous for the continuance of his appropriations. The same free intercourse was also used in a direct way for the futherance of his researches, for he was alert to the possibilities of knowledge from all sources, and found in his interviews with farmers, manufacturers, and miners valued opportunities for adding to his own store of information.

His devotion to practical science, viewed from another side, was devotion to the interests of his State, and this devotion, combined with his simplicity of character, was the foundation of that public confidence which gave success to his advocacy of new measures and placed him in so many positions of responsibility and trust. The unselfishness of his devotion was illustrated not only by his refusal to abandon the public work for private work with great pecuniary advantage, but by his unwillingness to have an office created at his own request become to him a source of emolument. When he was appointed Director of the Agricultural Experiment Station he insisted that the amount of the salary attached to that position should be deducted from his salary as State Geologist.

From the University of New York he received the degree of Doctor of Philosophy; from Union College, Doctor of Laws. He was vice-president of the American Association for the Advancement of Science in 1888, presiding over Section E at the Cleveland meeting. He was elected to membership in this Academy in 1887. His noblest decoration was the gratitude and love of those among whom and for whom he labored—the people of his State.

His writings consist largely of official reports. His work on the geology and geography of New Jersey is published in thirty annual reports, covering the years 1854–1856 and 1863–1887; in the *Geology of New Jersey*, 1872; in the *Report on the Clay De-*

posits of Woodbridge, South Amboy, and other places in New Jersey, 1878; in a *Report on a Survey of the Boundary Line between New Jersey and New York, made in July and August, 1874;* in volume I of *The Paleozoic, Cretaceous, and Tertiary formations of New Jersey,* 1886, and in volume I of the *Final Report of the State Geologist,* 1888. His official papers on agriculture are contained in the annual reports of the State College of Agriculture and Mechanic Arts (afterward Rutgers Scientific School) from 1865 to 1888, and the annual reports of the State Agricultural Experiment Station from 1880 to 1888. His official contributions to climatology began in the reports of the Rutgers Scientific School and included monthly bulletins of the State Weather Service from 1886 to 1889.

The following list of unofficial or scattered papers is based in large part on the bibliography of his geological writings by John C. Smock, contained in volume 5 of the Bulletin of the Geological Society of America:

Experiments and Observations made upon the Onondaga Brines: *Annual Reports of the Superintendent of the Onondaga Salt Springs of New York,* 1850, 1851; 1853, January; 1853, December, and 1861.

On the Subsidence of the Land on the Seacoast of New Jersey and Long Island: *Am. Jour. Sci.,* vol. xxiv, 1857, pp. 341-354; also *Can. Nat.,* vol. 2, 1857, pp. 258-261.

On the Probable Age of the White Limestone at Sussex and Franklin Zinc Mines, New Jersey: *Am. Jour. Sci.,* vol. xxxii, 1861, pp. 208, 209.

Soils of New Jersey and their Distribution. Fertilizers. Improved and Unimproved Lands in New Jersey: *First Ann. Rep. New Jersey State Board of Agriculture,* 1874, pp. 11–54.

Report on Fertilizers and on the College Farm: *Second Ann. Rep. New Jersey State Board of Agriculture,* 1874, pp. 5–34.

Soils and their Composition. Lime. Greensand Marl: *Third Ann. Rep. New Jersey State Board of Agriculture,* 1875, pp. 27–59.

Marls: *Ibid.,* 1877, pp. 45–138.

The Southern Limit of the Last Glacial Drift across New Jersey and the Adjacent Parts of New York and Pennsylvania: *Trans. Am. Inst. Min. Eng.,* vol. vi, May, 1877, pp. 467–470.

Catalogue of the Geological Survey Exhibit of New Jersey: *Rep. New Jersey Com. Cent. Ex.,* 1877, pp. 217–304.

Shell or Calcareous Marls: *Fourth Ann. Rep. New Jersey State Board of Agriculture*, 1877, pp. 16–54.

Report on the College Farm, 1877–1878: *Sixth Ann. Rep. New Jersey State Board of Agriculture*, 1879, pp. 13–26.

Agriculture in Europe—Report on Agriculture and Agricultural Teaching in Europe: *Ibid.*, pp. 27–108.

The Change of Relative Level of the Ocean and the Upland on the Eastern Coast of North America: *Proc. Am. Asso. Adv. Sci.*, 1882, pp. 400–408.

Report of the New Jersey Commissioners concerning the Northern Boundary Line between the States of New York and New Jersey, 1883, pp. 3–19. [This report is signed by George H. Cook and five other commissioners.]

[With John C. Smock] New York [Building Stones]: *Tenth Census of the United States, Report on Building Stones, etc.*, 1884, pp. 129–139.

[With John C. Smock] New Jersey [Building Stones]: *Ibid.*, pp. 139–146.

Explanatory statements, with maps [on the Location and Boundaries of East New Jersey]: *Bicentennial of the Board of American Proprietors of East New Jersey*, 1885, pp. 45–55.

Address on the Agricultural College: *Twelfth Ann. Rep. New Jersey State Board of Agriculture*, 1885, pp. 71–73.

The Protection of our Forests from Fires: *Fifteenth Ann. Rep. New Jersey State Board of Agriculture*, 1888, pp. 289–313.

On the State Weather Service: *Ibid.*, pp. 280–283.

Report of Subcommittee on Mesozoic: *Congrès Géol. Int., 4th session, London*, 1888, pp. 161–165.

On the International Geologic Congress and our part in it as American Geologists: *Proc. Am. Asso. Adv. Sci.*, vol. 37, 1889, pp. 159–177.

MEMOIR

OF

GEORGE BROWN GOODE.

1851-1896.

BY

S. P. LANGLEY.

READ BEFORE THE NATIONAL ACADEMY, APRIL 21, 1897.

BIOGRAPHICAL MEMOIR OF GEORGE BROWN GOODE.

George Brown Goode was born at New Albany, Indiana, on February 13, 1851, and died at his home in Washington on September 6, 1896, after a life of forty-five years, than which few human lives have ever been better filled.

In those years he won the warm affection of a wide circle of friends and the trust and confidence of a multitude of subordinates in the position to which his own abilities had carried him. He interested himself and interested others in ever-widening circles of research, and such varied work that it seemed to those who knew what he was doing, incomprehensible that one man could accomplish so much in one single life; and when this came to an end its cessation was like the loss of a part of themselves to those who knew him best, by whom he is remembered with an affection which men rarely gain from one another.

He was the son of Francis Collier Goode and Sarah Woodruff Crane. The Goode family trace their ancestry in this country to John Goode, of Whitby, who settled in Virginia prior to 1661.*

While still settled in Virginia, many members of the Goode family went to the South and West to do pioneer work in building up villages and towns on what was then the outskirt of civilization.

Dr. Goode's father, Francis Collier Goode, was born in Waynesville, Ohio, and was a merchant in Ohio and Indiana. In 1857 he retired from business, removing to Amenia, New York; subsequently to Middletown, Connecticut, and later to Arlington,

* The history of this family has been carefully traced by Dr. Goode in "Virginia Cousins: A Study of the Ancestry and Posterity of John Goode, of Whitby, a Virginia Colonist of the Seventeenth Century, with notes upon related families, a key to southern genealogy and a history of the English surname Gode, Goad, Goode, or Good from 1148 to 1887, by G. Brown Goode, with a preface by R. A. Brock, Secretary of the Virginia and Southern Historical Societies. Richmond, Virginia, J. W. Randolph & English," MDCCCLXXXVII.

Florida, and occasionally spent winters in the Bermudas, Tennessee, North Carolina, Virginia, and Washington city.

His mother, Sarah Woodruff Crane, was a descendant of Jasper Crane, who came to New England during the first ten years of the first settlement, and was one of the pioneers of Newark, New Jersey.

Dr. Goode was thus of sturdy American parentage on both sides, numbering among his ancestors the founders of the Virginia, Massachusetts, Connecticut, and New Jersey colonies. The family was singularly free from foreign mixture, not 10 per cent. of the marriages among the numerous descendants having been with persons whose ancestors came to America later than 1725.*

He passed his early childhood in Cincinnati and his later childhood and early youth in Amenia, New York, where he was prepared for college by private tutors. His father was a man of studious habits and not devoid of an interest in science. He had assembled in his library a set of the Smithsonian Reports, which young Goode read as a boy. It was through these volumes that he was first attracted to science and to the Smithsonian Institution, his boyish ambition being to become connected with it and to study under Professor Baird.

He entered Wesleyan University at Middletown, Connecticut, in 1866, and was graduated in 1870. Although scarcely more than fifteen when he entered college and a little over nineteen years of age at the time of his graduation, being the youngest member of the class, his work in the studies of the natural history group was so satisfactory as to attract the favorable notice of his teachers. The years at Middletown foreshadowed the strong love for nature, the museum interest, ability in classification, and even the literary talent, which were the distinguishing features of all Dr. Goode's later career.

When he went to college his father removed to Middletown and became a neighbor to Orange Judd, the pioneer of agricultural journalism in this country and closely identified with the advancement of scientific agriculture. There sprang up between the daughter of Mr. Judd and young Goode a friendship which ripened into love and resulted in their marriage, of which I speak here because Dr. Goode himself felt that the friendship with

* "Virginia Cousins," p. xiv.

Mr. Judd, thus brought about through his daughter, had the largest share in determining his future career. The two young people had similar tastes in natural history and outdoor life. As early as 1869 Dr. Goode commenced to record in the "College Argus" and the "College Review" his outdoor rambles. He was at this time a young man of stout frame and vigorous health, engaging in all of the athletic sports known to college students of that day.

In 1870 he entered Harvard University as a post-graduate student under Professor Louis Agassiz, whose genial influence he glowingly describes in his youthful letters.

Mr. Judd had presented to Wesleyan University a building, known as the Orange Judd Hall of Natural Science. This building was in progress of erection during Mr. Goode's student years and was dedicated in the commencement week of 1871. "Before that time," says Professor Rice, "the natural history collections of Wesleyan University were scattered in several buildings, very imperfectly labeled and arranged, and mostly inaccessible to students or visitors. The spacious rooms in Judd Hall first gave the opportunity to arrange and display these collections in such manner as to give them the dignity of a museum." The work which Dr. Goode had done while a student under Professor Agassiz caused an invitation to be extended to him to undertake the arrangement of this collection, and in 1871, when but a little over twenty, he was given the title of Curator of the Museum, and undertook the installation of the collections. It was in this work that he "first showed that genius for museum administration which he was destined afterward to display in the larger field." He retained his official connection with Middletown until 1877, although the greater part of these years was spent either in Washington or in the field. During a portion of this time, although absent from Middletown, he received a salary from Wesleyan University and was allowed in exchange to send to the Museum duplicates of natural history specimens in the Smithsonian Institution, as well as the duplicates of the collections which he made. He always retained a strong feeling of affection for his alma mater, and founded the Goode prize, intended to stimulate an interest in biologic studies. He was one of the editors of the 1873 and 1883 editions of the Alumni Record of Wesleyan University, and received the honorary degree of Doctor of Laws from that institution in 1893.

Dr. Goode's mother died in his infancy, and he found in his father's second wife an affectionate and sympathetic helper, who was a strong believer in the possibility of his future scientific career. To her he owed his introduction to Professor Baird, whom he first saw at Eastport, Maine, in 1872, and this meeting was the turning point of his professional life. Through it he not only got the larger opportunities for natural history work afforded by the Fish Commission and the Smithsonian Institution, but Professor Baird singled him out almost from the first as his chief pupil, his intimate friend, his confidential adviser, and his assistant in all the natural history work in which he was engaged. The splendid advantages which Professor Baird accorded his young friend were repaid by an intense devotion.

Mr. Goode said once that he could lay down his life for such a man, and indeed he almost did so, for his originally robust health was impaired by this devotion to Professor Baird's service, particularly at the Philadelphia Exposition of 1876, which he left invalided, and the effects of his overwork in which left him a weaker man through his after life. The death of Professor Baird in 1887 affected him so deeply that it was not until 1895 that he was once heard to say that he had but just recovered from the loss.

He became in 1872 a volunteer in the United States Fish Commission, the year after the organization of that bureau, and he continued this work, making collections in 1872 at Eastport, Maine, in 1873 in Casco bay, and in 1874 at Noank, on Long Island sound. The years from 1872 to 1878 show collections of fishes made by him at the points named, as well as in Bermuda, Florida, Connecticut, and other places. Nearly twenty papers and articles relating to the Fish Commission and to fisheries appeared from his pen during the first four years of this voluntary association with the Fish Commission. He was interested not only in the scientific side of ichthyological work, but devoted great attention to the economic side. It was in 1877 that he found his first specimen of a deep-sea fish and laid the foundation of the studies which culminated in the splendid memoir on "Oceanic Ichthyology" by himself and Dr. Bean. During these years with Professor Baird he became experienced in all the work of the Fish Commission, and upon his death was appointed Commissioner of Fisheries by the President. The position up to this time had been an honorary one, but Mr. Goode informed President Cleveland that the work had grown to such an extent that it was not possible for any person who was actively engaged in the Smithsonian Institution or elsewhere to continue it. President Cleveland urged him several times to permanently accept the position of Commissioner of Fisheries, and the Committee on Appropriations of Congress had provided a salary which was larger than the one which Mr. Goode was receiving or ever did receive, but he resolutely declined, asserting that his life's ambition had been to become associated with the Smithsonian Institution; that his heart was in the Museum, and that he could not give it up. As related to his work in the Fish Commission, the facts may be mentioned that in 1877 he was employed by the Department of State on statistical work in connection with the Halifax Commission, and in 1879 and 1880 he was in charge of the Fisheries Division of the Tenth Census. His administrative abilities were strongly brought out in the organization of this work. Professor Henry F. Osborn describes his method as follows: "Special agents were sent out to every part of the coast and to the Great Lakes to gather information. Goode worked at it himself on Cape Cod and manifested the same enthusiasm as in every other piece of work he took up. He interested himself in getting together a collection representing the methods of the fisheries and the habits of the fishermen. Neglecting neither the most trivial nor important objects, branching out into every collateral matter, he showed his grasp both of principles and of details." He was United States Commissioner to the Internationale Fischerei Ausstellung in 1880 at Berlin and to the International Fisheries Exposition held at London in 1883. From circular order No. 139, issued by Commander J. J. Brice, United States Commissioner of Fish and Fisheries, I extract the following sentences: " Dr. Goode is best known for his researches and publications on the fishes and fisheries of the United States, on which subjects he came to be recognized as the leading authority. . . . He has been one of the most fruitful and valued contributors to the reports and bulletins of the Fish Commission, and in his death the fishing interests of the country have sustained a severe loss."

As I have before said, his connection with the Smithsonian

Institution followed shortly after the acquaintance with Professor Baird, who invited him to spend the winter of 1873 in Washington for the purpose of arranging the ichthyological specimens and with the understanding that as a payment for this service he was to be allowed to select duplicates for the museum at Middletown. At that time he had the title of Assistant Curator, which was later changed to Curator, and, although the relations to Middletown continued, the ties with the Institution were becoming stronger and stronger. He now met Professor Henry for the first time, and became one of the small coterie of Smithsonian men who at that time lived in the Smithsonian building and formed a part of the hospitable household which Professor Henry maintained. In these early days the staff was an extremely small one, being only thirteen persons, including honorary collaborators and subordinates. Dr. Goode threw himself into this work with uncalculating devotion. Professor Baird's duties were becoming more and more numerous, and after he became Secretary of the Institution Dr. Goode took the Museum work upon his willing shoulders. In 1881, when the new Museum building was completed and the United States National Museum really organized, Mr. Goode, then thirty years of age, was made Assistant Director. In that year he prepared a circular, known as Circular No. 1 of the National Museum, which set forth a scheme of administration for the Museum so comprehensive in its scope, so exact in its details, so practical in its ideas that it is with but few modifications still the guide for the Museum staff. On January 12, 1887, Professor Baird, whose health was then failing, appointed Mr. Goode as Assistant Secretary of the Smithsonian Institution in charge of the National Museum, and from that time until his death he had the fullest charge of the entire administration of the Museum.

It is hard to say whether Mr. Goode was best known as a museum director or a naturalist. I of course had more occasion to see his work from the administrative side. It would be impossible to understand his success in this field without thinking of the character of the man, and here I may repeat what I have said elsewhere, that if there was one quality more than another which formed the basis of his character it was sincerity—a sincerity which was the ground of a trust and confidence such as could be instinctively given even from the first only to an absolutely loyal and truthful nature.

I do not know whether a power of reading character is more intuitive or acquired, but at any rate, without it men may be governed, but not in harmony, and must be driven rather than led. Dr. Goode was in this sense a leader, quite apart from his scientific competence. Every member of the force he controlled, not only among his scientific associates, but down to the humblest employés of the Museum, was an individual to him, with traits of character which were his own and not another's, and which were recognized in all dealings, and in this I think he was peculiar, for I have known no man who seemed to possess this sympathetic insight in such a degree, and certainly it was one of the sources of his strength.

I shall have given, however, a wrong idea of him if I leave any one under the impression that this sympathy led to weakness of rule. He knew how to say "no," and said it as often as any other, and would reprehend, where occasion called, in terms the plainest and most uncompromising a man could use, speaking so when he thought it necessary, even to those whose association was voluntary, but who somehow were not alienated as they would have been by such censure from another. "He often refused me what I most wanted," said one of his staff to me; "but I never went to sleep without having in my own mind forgiven him."

I have spoken of some of the moral qualities which made all rely upon him and which were the foundation of his ability to deal with men. To them was joined that scientific knowledge without which he could not have been a Museum administrator; but even with this knowledge he could not have been what he was, except from the fact that he loved the museum and its administration above every other pursuit, even, I think, above his own special branch of biological science. He was perhaps a man of the widest interests I have ever known, so that whatever he was speaking of at any moment seemed to be the thing he knew best. It was often hard to say, then, what love predominated; but I think that he had, on the whole, no pleasure greater than that in his Museum administration, and that, apart from his family interests and joys, this was the deepest love of all. He refused advantageous offers to leave it, though I ought to gratefully add, that here his knowledge of my reliance upon him and his unselfish desire to aid me were also among his determining motives in remaining. They were natural ones in such a man.

What were the results of this devotion may be comprehensively seen in the statement that in the year in which he was first enrolled among the officers of the Museum the entries of collections numbered less than two hundred thousand, and the staff, including honorary collaborators and all subordinates, thirteen persons, and by comparing these early conditions with what they became under his subsequent management.

Professor Baird at the first was an active manager, but from the time that he became Secretary of the Institution he devolved more and more of the Museum duties on Dr. Goode, who for nine years preceding his death was in practically entire charge of it. It is strictly within the truth, then, to say, that the changes which have taken place in the Museum in that time are more his work than any other man's; and when we find that the number of persons employed has grown from thirteen to over two hundred, and the number of specimens from two hundred thousand to over three million, and consider that what the Museum now is, its scheme and arrangement, with almost all which make it distinctive, are chiefly Dr. Goode's, we have some of the evidence of his administrative capacity. He was fitted to rule and administer both men and things, and the Museum under his management was, as some one has called it, "A house full of ideas and a nursery of living thought."

" His success of administration," says Professor Osborn, " also came partly from an instinctive knowledge of human nature. . . . He sought out the often-latent best qualities of the men around him and developed them. When things went out of joint and did not move his way, he waited with infinite patience for the slow operation of time and common sense to set them right. He was singularly considerate of opinion, . . . fertile of original ideas and suggestions, full of invention and of new expedients, studying the best models at home and abroad, but never bound by any traditions of system or of classification. . . . To all his work also he brought a refined artistic taste, shown in his methods of printing and labeling, as well as in his encouragement of the artistic, and therefore the truthful and realistic development of taxidermy in the arrangement of natural groups of animals. To crown all, like Baird he entered into the larger conception of the wide-reaching responsibilities of his position under the Government, fully realizing that he was not at the head of a university or of a metropolitan museum, but of the Museum of a great Nation. Every reasonable request from another institution met a prompt response. . . . Not the advancement of Washington science, but of American science, was his dominating idea."

There was no subject in connection with the administration of the Museum to which he did not at some time or other give his personal attention. He had a quick eye for color and for form, understood the art of decorating and case-building, and had besides a special knowledge of subjects so widely remote from his own biologic interests that it is a question whether a new species or a new musical instrument gave him the greater pleasure. So fully could I rely on his judgment in all things, that even in matters not connected with the Museum I frequently sought the benefit of his advice, and this was sure to be sound, whether it related to the typography or paper of a new volume of the publications, or to some weighty question of policy. It is difficult to single out from among the manifold matters relating to the Institution proper which were confided to him one single thing. I cannot, however, but recall the fact that he seemed to me, both because of the soundness of his judgment and the wide domain of science with which he was acquainted, the fittest person to place in charge of the Hodgkins award made two years ago. To this entire work, from the time of Mr. Hodgkins' gift, down to the closing of the award, Mr. Goode gave unremitting and zealous attention, having served as chairman both of the preliminary committee and the committee on award.

The field of natural history, of antiquities, of art, of books, is so vast that a mere assemblage of objects, of books, of prints, of engravings, is not in itself significant. Collecting is an art which many essay but few attain. Mr. Goode was eminently a collector. As early as 1872 we find him collecting the fishes of the Bermudas, which he worked up in a catalogue, giving in each case, in addition to characteristics previously noted, descriptions of the colors of the fishes while living, notes on the size and proportions, observations of habits, hints in reference to the origin and meaning of their popular names, and notes upon modes of capture of economic value. The same careful methods of collection he followed in the subsequent expeditions which he undertook in the field. It was not alone in natural history, however, that this talent for collecting displayed itself. Every possible sort of specimen or information which was at hand he collected. He would bring back from every exposition which he attended methodical collections, frequently of materials overlooked by others. Every visit to a foreign country resulted in the bringing back of a collection, not of miscellaneous objects, but of a series which could themselves be placed on exhibition. These might be musical instruments, ecclesiastical art, early printed books, medals, or ivories, and the same taste and discrimination and good judgment were displayed in their selection. He collected, however, not only objects, but also words and ideas. From the assembling of the common names of plants and animals in America, there grew a large collection of Americanisms, probably larger than any single collection published. Portraits of scientific men, portraits of Washington and Jefferson, autographs, Confederate imprints, Americana, American scientific text-books—these are but a few of the fields in which Dr. Goode collected.

He was a naturalist in the broadest sense of that word, following in the footsteps of Agassiz and Baird. "He had," says Dr. Gill, "acquaintance with several classes of the animal kingdom, and especially with the vertebrates. He even published several minor contributions on herpetology, the voice of crustacea, and other subjects. . . . The flowering plants also enlisted much of his attention, and his excursions into the fields and woods were enlivened by knowledge of the subjects he met with." "The designation naturalist," says Professor Osborn, "was one which Goode richly earned and which he held most dear, and our deep sorrow is that his activity as naturalist extended only over a quarter of a century." . . . "As a naturalist, Goode did not close any of the windows opening out into Nature. His broad spirit in public affairs displayed itself equally in his methods of field and sea work and in the variety of his observations and writings. While fishes became his chief interest, he knew all the eastern species of birds after identifying and arranging the collection in his college museum. He loved plants, and in the later years of his life took great pleasure in the culture of the old-fashioned garden around his house. . . . Many of his briefer papers deal directly with the biological problems which attracted his interest, especially among reptiles and fishes, touching such questions as migration, coloring, albinism, mimicry, parasitism, feeding and breeding habits, the relation of forest protection to the protection of fishes."

Perhaps no one can be a "naturalist" in the larger sense without being directly a lover of Nature and of all natural sights and sounds. One of his family says, "He taught us all the forest trees, their fruits and flowers in season, and to know them when bare of leaves by their shapes; all the wayside shrubs, and even the flowers of the weeds; all the wild birds and their notes, and the insects. His ideal of an old age was to have a little place of his own in a mild climate, surrounded by his books for rainy days, and friends who cared for plain living and high thinking, with a chance to help some one poorer than he." He was a loving and quick observer, and in these simple, natural joys, his studies were his recreations, and were closely connected with his literary pursuits.

He was of course first and foremost an ichthyologist, and this through no lack of sympathy with the larger field, but because of the recognition of the fact that the larger field could not be successfully covered by one man.

His adherence to this subject as a specialty was undoubtedly determined by his long and intimate connection with the Fish Commission during the period of greatest advancement in methods of deep-sea exploration, the rich collections of fishes derived from that source being placed at his command. The novelties of structure and environment presented by this material, ever increasing as the work progressed, proved an attraction too strong to be resisted, even in the face of his varied official duties, and caused him to become distinctively a student of the marine forms.

His observations were not confined to any single branch of the subject, but were given the widest latitude that his time permitted. He was the discoverer of many new and strange species and an acknowledged authority on classification, but he took perhaps the greatest interest in questions regarding the geographical and bathymetrical distribution of fishes, a field in which his opportunities for investigation had been unexcelled. The color of fishes had also been a favorite study with him, and he had paid attention to many points in their morphology and in the functions of special organs. He was especially well versed in the literature of ichthyology from the earliest times, and, after Professor Baird, was the most eminent exponent in this country of the benefits to be secured to the practical fisheries through the application of scientific teachings.

Dr. Gill in reviewing his scientific career said: "A 'Catalogue of the Fishes of the Bermudas,'[1] published in 1876, furnished additional evidence of knowledge of the literature of his subject and ability to use it to advantage in the discussion of mooted questions, and it also evinced his power of observation.

"In the same year, 1876, appeared another work which to a still greater degree rendered manifest those same mental characteristics. The work was only a catalogue, but perhaps from no other publication can some intellectual qualities be so readily and correctly gauged by a competent judge as an elaborate catalogue. Powers of analysis and synthesis, and the ability to weigh the relative values of the material at hand, may make a 'mere catalogue' a valuable epitome of a collection and of a science. Such a production was the 'Classification of the Collection to illustrate the Animal Resources of the United States,'† a work of 126 pages. Three years later this catalogue served as the basis for and was elaborated and expanded into a large 'Catalogue of the Collection to illustrate the Animal Resources and the Fisheries of the United States,'‡ a volume of 351 pages.

[1] Catalogue of the Fishes of the Bermudas, based chiefly on the collections of the United States National Museum. . . . Washington: Government Printing Office, 1876 (8°, pp. (2) 1–82, Bulletin United States National Museum, No. 5).

† International Exhibition, 1876. Board in behalf of United States Executive Departments. Classification of the Collection to illustrate the Animal Resources of the United States: A list of substances derived from the animal kingdom, with synopsis of the useful and injurious animals and a classification of the methods of capture and utilization. . . . Washington: Government Printing Office, 1876 (8°, pp. 126, a Second edition with supplementary title as Bulletin No. 6, United States National Museum).

‡ International Exhibition, 1876. Catalogue of the Collection to illustrate the Animal Resources and the Fisheries of the United States, exhibited at Philadelphia in 1876 by the Smithsonian Institution and the United States Fish Commission, and forming a part of the United States National Museum. . . . Washington: Government Printing Office, 1879 (8°, pp. 351 (1), Bulletin United States National Museum, No. 14).

These catalogues were for the tentative and adopted arrangement of material exhibited by the Smithsonian Institution and the United States Fish Commission at the 'International Exhibition, 1876.'

"It was the ability that was manifested in these catalogues and the work incidental to their preparation that especially arrested the attention of Professor Baird and marked the author as one well adapted for the direction of a great museum. For signal success in such direction special qualifications are requisite. Only some of them are a mind well trained in analytical as well as synthetic methods, an artistic sense, critical ability, and multifarious knowledge, but above all, the knowledge of men and how to deal with them. Perhaps no one has ever combined in more harmonious proportions such qualifications than G. Brown Goode. In him the National Museum of the United States and the world at large have lost one of the greatest of museum administrators.

"As a naturalist, the attention of Dr. Goode was especially directed to and even concentrated on the fishes. His memoirs, contributed mostly to the Proceedings of the United States National Museum, were numerous and chiefly descriptive of new species. (For many of these he had as a collaborator Dr. Tarleton Bean, then the curator of fishes of the United States National Museum.) Some of the memoirs, however, dealt with special groups, as the Menhaden (1879), Ostraciontidæ (1880), Carangidæ (1881), the Swordfishes (1881), and the Eel (1882). His monograph of the Menhaden (*Brevoortia tyrannus*), contributed originally to the Report of the United States Commissioner of Fisheries * and then published as a separate work †—a large volume of nearly 550 pages and with 30 plates—is a model of critical treatment of information collected from all quarters; but

* The Natural and Economical History of the American Menhaden. In Report United States Commission of Fish and Fisheries, part V, 1879, Appendix A, pp. 1–529, pls. i–xxxi (xxx canceled), pp. 194–267 by Professor W. O. Atwater.

† American Fisheries: A History of the Menhaden, by G. Brown Goode, with an account of the Agricultural Uses of Fish by W. O. Atwater . . . And an introduction, bringing the subject down to date. Thirty plates. New York: Orange Judd Company, 1880 (8°, pp. x (i), iii–xii, 1–529 (1), 31 pls., pl. 30 canceled).

his most important contributions were published as official Government reports and were the results of investigations especially undertaken for such reports. Especially noteworthy were the volumes comprising the results of the Census of 1880.

"The 1880 Census was planned and carried out on an unusual scale. For the fisheries the United States Commission of Fish and Fisheries coöperated, and Dr. Goode had general charge of the entire work. The assistants and special agents were consequently selected with judgment, and the results were very valuable. The huge mass of statistics was digested and condensed in seven large quarto volumes, representing five sections separately devoted to special branches of the subject.*

"Dr. Goode's cares were mainly concentrated on the first section, treating of the 'Natural History of Aquatic Animals,' which was discussed in over 900 pages of text and illustrated by 277 plates. This work was by far the mose complete survey of the economical fishes of the country that had ever appeared, and has since been the most prized; it led to another.

"After the appearance of the census volumes, Dr. Goode was urged to prepare a work for popular use. His consent to do so was followed by a volume, entitled 'American Fishes, a popular treatise upon the game and food fishes of North America,'† published by the Standard Book Company of New York. Inasmuch as none of the previous popular works on the American fishes had emanated from men of scientific eminence, it scarcely need be added that the new work had no rival in the field, so far as accurate information and details of habits were involved.

"A short time previously Dr. Goode had also prepared the text to accompany a series of twenty large folio colored portraits by

* The Fisheries and Fishery Industry of the United States. Prepared through the coöperation of the Commissioner of Fisheries and the Superintendent of the Tenth Census. By George Brown Goode, Assistant Director of the United States National Museum, and a staff of associates. Washington: Government Printing Office, 1884 (–1887, 5 sections in 7 volumes). "Section 1, Natural History of Aquatic Animals," was mainly prepared by Dr. Goode.

†American Fishes: A popular treatise upon the game and food fishes of North America, with especial reference to habits and methods of capture, by G. Brown Goode, with numerous illustrations. New York: Standard Book Company, 1888 (8°, xvi + 496 pp., colored frontispiece).

an eminent artist, Mr. S. A. Kilbourne, of the principal 'Game Fishes of the United States.' *

" Never had investigations of the deep sea been conducted with such assiduity and skill as during the last two decades The chief honors of the explorations were carried off by the British and American Governments. As the fishes obtained by the vessels of the United States Fish Commission were brought in they were examined by Dr. Goode (generally in company with Dr. Bean) and duly described. At length Drs. Goode and Bean combined together data respecting all the known forms occurring in the abysmal depths of the ocean, and also those of the open sea, and published a résumé of the entire subject in two large volumes entitled 'Oceanic Ichthyology.' †

" This was a fitting crown to the work on which they had been engaged so long, and the actual publication only preceded Dr. Goode's death by about a fortnight.

" But the published volumes did not represent all the work of Dr. Goode on the abyssalian fishes. He had almost completed an elaborate memoir on the distribution of those fishes, and, contrary to the conclusions of former laborers in the same field, had recognized for them a number of different faunal areas. It is to be hoped that this may yet be given to the world.

" Morphological and descriptive ichthyology were not cultivated to the exclusion of what is regarded as more practical features. In connection with his official duties as an officer of the United States Fish Commission he studied the subject of pisciculture in all its details. Among his many contributions to the subject are one on 'The First Decade of the United States Commission, its plan of work and accomplished results, scien-

* Game Fishes of the United States, by S. A. Kilbourne; text by G. Brown Goode. New York: Published by Charles Scribner's Sons, 1879–1881. (Folio, 46 pp., 20 plates, and map, published in ten parts, each with 2 plates, lithographs in water color, and four-page folio of text.)

† Smithsonian Institution. United States National Museum. Special bulletin. Oceanic Ichthyology: A Treatise on the Deep-sea and Pelagic Fishes of the World, based chiefly upon the collections made by the steamers *Blake*, *Albatross*, and *Fish Hawk* in the Northwestern Atlantic, with an atlas containing 417 figures, by George Brown Goode, Ph. D., LL. D., and Tarleton H. Bean, M. D., M. S. Washington: Government Printing Office, 1895, 2 vols., 4°; I, xxxv + 26, 553 pp.; II, xxiii + 26 pp., 123 pl.

tific and economical' (1880), another treating of the 'Epochs in the History of Fish Culture' (1881), and two encyclopædic articles 'The Fisheries of the World' (1882), and the one entitled 'Pisciculture,' in the Encyclopædia Britannica (1885)."

"The great work of his life, 'Oceanic Ichthyology,'" says Dr. Jordan, "was, however, written during the period of his directorship of the National Museum, and it was published but a month before his death. Almost simultaneously with this were other important publications of the National Museum, which were his also in a sense, for they would never have been undertaken except for his urgent wish and encouragement. If a personal word may be pardoned, 'The Fishes of North and Middle America,' which closely followed 'Oceanic Ichthyology,' would never have been written except for my friend's repeated insistance and generous help.

"The first recorded scientific paper of Dr. Goode is a note* on the occurrence of the bill-fish in fresh water in the Connecticut river. The next is a critical discussion of the answers to the question, 'Do snakes swallow their young?' In this paper he shows that there is good reason to believe that in certain viviparous snakes the young seek refuge in the stomach of the mother when frightened, and that they come out unharmed when the reason for their retreat has passed.

"The first of the many technical and descriptive papers on fishes was the 'Catalogue of the Fishes of the Bermudas,'† published in 1876. This is a model record of field observations and is one of the best of local catalogues. Dr. Goode retained his interest in this outpost of the great West Indian fauna, and from time to time recorded the various additions made to his first Bermudan catalogue.

"After this followed a long large number of papers on fishes, chiefly descriptions of species or monographs of groups. The descriptive papers were nearly all written in association with his excellent friend, Dr. Tarleton H. Bean, then curator of fishes in the National Museum.

"In monographic work Dr. Goode took the deepest interest, and he delighted especially in the collection of historic data con-

* American Naturalist, vol. v, p. 487.

† Bulletin No. 5, United States National Museum.

cerning groups of species. The quaint or poetical features of such work were never overlooked by him. Notable among these monographs are those of the Menhaden, the Trunk-fishes, and the Sword-fishes.

" The economic side of science also interested him more and more. That scientific knowledge could add to human wealth or comfort was no reproach to him. In his notable monograph of the Menhaden* the economic value as food or manure of this plebeian fish received the careful attention which he had given to the problems of pure science.

" Dr. Goode's power in organizing and coördinating practical investigations was shown in his monumental work † on the American Fisheries for the Tenth Census, 1880. The work of the record of the fisheries and associated marine industries was placed in his hands by Francis A. Walker, Superintendent of the Census. Under Dr. Goode's direction skilled investigators were sent to every part of the coast and inland waters of the country."

His "American Fishes," a popular treatise upon the game and food fishes of North America, published in 1888, is deserving of a special mention both because of the charming literary style in which it is written as well as its scientific accuracy and excellence. The wealth and aptness of the chapter headings of this book show that Mr. Goode's wide reading was associated with everything which could illustrate his science on the literary side. He had a knowledge of everything even remotely connected with his ichthyological researches from St. Anthony's " Sermon to Fishes " to the literature of fish cookery, while in one of his earliest papers, written at nineteen, his fondness for Isaac Walton and his familiarity with him are evident.

While never claiming the title of anthropologist, he was yet a close student of the anthropological and ethnological work in this country and abroad, and it is not too much to say that no professional anthropologist had a higher ideal of what his science

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* " The Natural and Economical History of the American Menhaden." In Report of United States Commission of Fish and Fisheries, part 5. Washington, 1879.

† " The Fisheries and Fishery Industry of the United States." Prepared through the coöperation of the Commissioner of Fisheries and the Superintendent of the Tenth Census. Washington, 1884.

might come to be or exercised a more discriminating criticism on its present methods and conditions than did Dr. Goode. He was, moreover, not only interested in the biological problems of the anthropologist, but in technology and the history of art; the history of human invention and archæology were equally in his mind, and his suggestiveness in each of these fields could be attested by all of the anthropologists with whom he came in contact.

"It would be difficult," says Professor Mason, "to find among those who are professional anthropologists a man who had a more exalted idea of what this science ought to be. There is not perhaps another distinguished scholar who has endeavored to collect into one great anthropological scheme all of the knowledge of all men in all ages of the world and in all stages of culture."

Dr. Goode was peculiarly related to the management of expositions and did more than any other person in America to engraft upon them museum ideas and widen their scope from the merely commercial and industrial to the educational and scientific.

His first experience in this field was in 1876, at the Centennial Exhibition held in Philadelphia. Professor Baird was in charge of the exhibits of the Smithsonian Institution and Fish Commission, and being much occupied at the time with other matters, the greater part of the installation and other work connected with the exhibit was placed under the immediate supervision of Mr. Goode. The work done by the Smithsonian and Government Departments at this exhibition was pioneer work, it being the first international exhibition in which the United States Government was engaged. It is not too much to say that the arrangement of the Smithsonian exhibit at Philadelphia was the model on which all subsequent exhibits of the kind were based, and that the classification, the installation, and the arrangement have had a lasting influence on exhibition work everywhere. But every administrative activity of this sort was sure to result in some literary product, so that we find in 1876 Mr. Goode published "A Classification of the Collections to illustrate the Animal Resources of the United States: A list of substances derived from the animal kingdom, with synopsis of the useful and injurious animals, and a classification of the methods of capture and utilization." This work was afterwards published in an enlarged form as a bulletin of the National Museum.

His services as commissioner for the United States Government at the Fisheries Exhibition of Berlin in 1880 and London in 1883 have already been alluded to. These, too, resulted in several articles in German and in a bulletin of the Museum, while several addresses and papers delivered at the Conferences of the International Fisheries Exhibition in London were published in the papers of the conferences, and full reports were made by Dr. Goode on his return to this country and published at the Government Printing Office.

He was the representative of the Smithsonian Institution at all the subsequent exhibitions held in this country—Louisville, 1884; New Orleans, 1885; Cincinnati, 1888; Chicago, 1893, and Atlanta, 1895—serving also as a commissioner and for a time acting Commissioner General to the Columbian Exposition held at Madrid in 1892.

The exhibits made under his direction were never repetitions. Each one contained new material never shown before, and exhibited the progress of the Institution and Museum, as well as the advances made in the arts of taxidermy, installation, and labelling. Mr. Goode, too, always bore in mind the local interest, and endeavored to show specimens and materials which would be instructive to persons residing in the neighborhood of the place at which the exposition was held. Thus at Cincinnati objects were prominent which related to the Ohio valley, for Madrid he prepared an exhibit to illustrate the conditions of human and animal life in America at the time of the Spanish discovery, whilst at Atlanta especial stress was laid on showing the fauna, flora, archæology, and mineral resources of the south Atlantic states. He prepared the report on the Madrid Exposition, and at the request of the Government Commission drew up a provisional classification for the Chicago Exposition, which, while not formally accepted, was used throughout in the official classification, many pages being copied without a change. For the Chicago, as well as the Atlanta Exposition, he prepared a carefully written catalogue, and for the latter an excellently condensed sketch of the Smithsonian Institution.

Nowhere were Mr. Goode's administrative talents more strongly shown than in an exhibition. The plans of the floor space, the cases, the specimens were all carefully arranged in advance. Boxes were especially made of lumber which could be utilized for cases or platforms. Cases were marked, and not very long before the opening of the exposition the entire mass would be deposited on the bare space assigned to the Smithsonian exhibit. Usually other exhibitors had their material half arranged by this time, and the fear was expressed by sympathetic bystanders that the Smithsonian would not be ready. The cases would be unpacked and the specimens put in them in whatever position they happened to stand, and up to the last day all would seem to be in confusion; but Dr. Goode knew his resources and his men as a general knows his army. Suddenly all detailed work would come to an end, and in the course of a few hours, as if by magic, the entire exhibit would be put in place. He had a pardonable pride in this sort of generalship, for whether at Chicago or Atlanta it had never failed him, and it earned the highest encomiums at Berlin, London, and Madrid.

Dr. Goode's services at these various expositions were recognized by diplomas and medals, and from the Spanish government he received the order of Isabella the Catholic, with the grade of commander.

I have already spoken of Mr. Goode's administrative qualities as shown in his management of the National Museum; but his contributions to museum administration and the history of museums were not confined to his own work. From all parts of America and even as far distant as Australia his opinion was sought with regard to the plans for museum buildings as well as on minor matters of installation. All requests for such information and advice were fully answered in minute detail.

It was into his papers on museums that some of his best thoughts went, and it was there that we find epigrammatic statements which are constantly quoted by all interested in the matter.

The first paper by him on this subject appeared in the "College Argus" March 22, 1871. It was entitled "Our Museum," and was a description of the collection in Judd Hall. This article indicated plainly the museum instinct, for it was largely intended to make known the deficiencies in the collection, and pointed out how students and professors could make these good on their summer excursions. He also published a guide to this museum.

In 1888 he read before the American Historical Association a paper entitled "Museum History and Museums of History."

Here he traced the growth of the museum idea from the beginning down to the present time, repeating his now oft-quoted phrase, "An efficient educational museum may be described as a collection of instructive labels, each illustrated by a well selected specimen." Atlases of ethnological portraits and works like those of Audubon he described as " not books, but museum specimens masquerading in the dress of books."

Even more forcible was a lecture delivered before the Brooklyn Institute in 1889, entitled " Museums of the Future." " The museum of the past," he wrote, " must be set aside, reconstructed, transformed from a cemetery of bric-a-brac into a nursery of living thoughts." . . . " The people's museum should be much more than a house full of specimens in glass cases. It should be a house full of ideas, arranged with the strictest attention to system." . . . "A finished museum is a dead museum, and a dead museum is a useless museum."

Most noteworthy, however, was his paper contributed to the Museums' Association of Great Britain in 1895, entitled " The Principles of Museum Administration." This was a carefully prepared codification of " the accepted principles of museum administration," which Mr. Goode hoped would " be the cause of much critical discussion." The ideas were presented in the form of aphorisms and were exceptionally clear cut, ending with the assertion that " the degree of civilization to which any nation, city, or province has attained is best shown by the character of its public museums and the liberality with which they are maintained."

This paper was warmly welcomed by museum experts, many of whom testified by their letters the interest they had in the clear presentation of the principles which should guide the museum administrator. At the 1896 meeting of the same Association Mr. Bather said: " When I read the magnificently exhaustive address by Dr. G. Brown Goode, published in our last report, it was manifest that all the ideas I had ever had were anticipated in that masterly production; " whilst an obituary note in the same volume says, " His early death is a great loss, not only to the United States National Museum, but museums in general, for he took a deep and active interest in all things affecting their development and well-being."

The " Manchester Guardian," September 20, 1896, says: " He was a recognized authority on all matters affecting museum administration, and in this capacity he last year wrote a paper on the principles of museum management and economy, which was brought before the annual Congress of the Museums Association at Newcastle, and has since attracted much attention as an admirable exposition of the general theory of administration applicable to museum work in all its branches. It is of interest to note that Dr. Goode's definition of a museum is an institution for the preservation of those objects which best illustrate the phenomena of nature and the works of man, and the utilization of these for the increase of knowledge and for the culture and enlightenment of the people. In this spirit Dr. Goode worked, and he not only achieved much in his own country, but was also ever ready to cordially coöperate with foreign kindred institutions, especially those in England, for the advancement of museum work as a means of education."

These activities would have been sufficient for an ordinary man, but in addition he was the historian of American science.

In 1886 he delivered, as president of the Biological Society of Washington, an address entitled "The Beginnings of Natural History in America," tracing it from Thomas Harriott, who came to this country in 1585, reciting the scientific labors of Captain John Smith, John Ray, Thomas Jefferson, and a host of others. The spirit which actuated this address is well illustrated in the following paragraphs: "It seems to me unfortunate, therefore, that we should allow the value of the labors of our predecessors to be depreciated, or to refer to the naturalists of the last century as belonging to the unscientific or the archaic period. It has been frequently said by naturalists that there was no science in America until after the beginning of the present century. This is, in one sense, true; in another, very false. There were then, it is certain, many men equal in capacity, in culture, in enthusiasm to the naturalists of today, who were giving careful attention to the study of precisely the same phenomena of nature. The misfortune of the men of science in 1785 was that they had three generations fewer of scientific predecessors than we."

This address he followed up by a second, entitled "The Beginnings of American Science: The Third Century," delivered in 1888, also before the Biological Society. He divided the period from 1782 to 1888 into three periods, which he called after the names of Jefferson, Silliman, and Agassiz.

Continuing along this same line, he contributed to the American Historical Association, in 1890, a paper on "The Origin of the National Scientific and Educational Institutions of the United States."

The material contained in these various papers was summed up in an unpublished work entitled "What has been done for Science in America, 1492–1892," which illustrates in an interesting way the development of Dr. Goode's mind, for in this study as much attention is given to astronomy, physics, and even comparative philology as is paid to natural history. Parallel with this work may be mentioned a collection of portraits of almost every scientific man of importance mentioned in any of these four essays. Besides these, he wrote an article in the "Science News," 1878, entitled "The Earliest American Naturalist, Thomas Harriott."

He was greatly interested in American history, a close student of the writings of the fathers—more especially of Washington and Jefferson—and an enthusiastic investigator of Virginia history, for which he had assembled a great mass of original material. He was especially interested in the study of institutional history, which he thought approximated most nearly to the scientific method. It is more than likely that this interest grew out of his studies in genealogy, the most splendid result of which is his "Virginia Cousins," though a great mass of material, still unpublished, attests the fact that these genealogical collections were intended to cover the South and to serve as a contribution to southern history. He relates in the prologue to his "Virginia Cousins" that his interest in the Goode family tree was awakened in him by his father at the age of twelve.

The significance of genealogical studies for American history he recognizes in the following words: "The time is coming when the sociologist and the historian will make an extensive use of the facts so laboriously gathered and systematically classified by genealogists, and it is probable that this can be better done in the United States than elsewhere;" and again, "One of the elements of satisfaction in genealogical study legitimately arises from the success of our attempts to establish personal relations with past ages and to be able to people our minds with the images of our forefathers as they lived two, three, four hundred years ago."

But there was a scientific interest which attached to this work, as well as an historical one, for Dr. Goode was a strong believer in heredity, and he was profoundly impressed with the idea that man's capabilities and tendencies were to be explained by the characteristics of the men and women whose blood flowed through their veins.

This idea, too, is brought out strongly in his biographical work, nowhere more strongly than in his biographies of Henry, Baird, and Langley (almost the last work he ever did) for the Smithsonian Half Century Book, and it is carefully worked out in an elaborate plan of a biography of Professor Baird, which would probably have been the next literary work he would have undertaken had his life been spared.

He was greatly interested in bibliography, his methods in this science being most exact. He published bibliographies of Spencer Fullerton Baird, Charles Girard, Philip Lutley Sclater, and had under way bibliographies of Theodore Gill and David Starr Jordan. "A gigantic work in the same line," says Dr. Gill, "had been projected by him and most of the materials were collected; it was no less than a complete bibliography of ichthyology, including the names of all the genera and species published as new. In no way may ichthyology at least more feel the loss of Goode than in the loss of the complete bibliography."

Mr. Goode was a student of the history of the scientific societies, and was himself deeply interested in their welfare. In all the Washington scientific societies he was an active member, serving as president both of the Biological Society and the Philosophical Society, before which he delivered his notable address on the history of American science. He also belonged to the Anthropological and Geographic Societies of Washington and stoutly maintained the traditions of all these. He was elected a member of the National Academy of Sciences in 1888, was for many years a member of the Association for the Advancement of Science, being elected vice-president of the Zoölogical Section last summer, a few days before his death. He was a member of the American Philosophical Society, of the American Society of Naturalists, and a Fellow of the American Academy of Arts and

Sciences, and among foreign societies he had been honored by election to the Société des Amis des Sciences Naturelles de Moscou, Société Zoölogique de France, Zoölogical Society of London, and the Société Scientifique du Chile.

He seemed to regard historical and patriotic societies with an equal interest, being a member of the council of the American Historical Association and a member of the Virginia Historical Society and the Columbian Historical Society of Washington and of the newly formed Southern Historical Society. His work in connection with the hereditary and patriotic societies was so especially near to him as to demand an unusual mention. He was one of the organizers of the Sons of the American Revolution of the District of Columbia, holding the offices of vice-president general and registrar general in the national society, and at the time of his death of president in the local society. He stimulated this society to issue historical publications, and saw a number through the press himself. A society known as the Sons of the Revolution having been founded with somewhat similar aims, Mr. Goode joined this organization with the avowed purpose of bringing them together. In this society he held the office of vice-president. He was lieutenant governor of the Society of Colonial Wars of the District of Columbia. He gave constant advice to the Daughters of the American Revolution during the period of their organization, and was instrumental in having the State of Massachusetts present, as a home for the Daughters of the Revolution in Georgia, its building at the Atlanta Exposition, which was a copy of the old Craigie house in Cambridge, once occupied by Washington as his headquarters, and later the residence of Longfellow. The success of this effort gave him special pleasure, for he regarded it as one of the means for promoting friendliness between the people of New England and the people of the South.

Although these numerous duties and activities would seem to have been more than enough for any single man, Mr. Goode did not stop here. Every scientific activity of the Government had at some time or other the advantage of his wise counsel and his active coöperation. His public duties outside of the Smithsonian in connection with the Department of State, the Fish Commission, the Census, and the various expositions abroad at which he represented this Government I have already alluded to; but he was possessed of a higher order of patriotism which even this service did not satisfy. Mr. William L. Wilson, Regent of the Smithsonian Institution, lately Postmaster General of the United States and president of Washington and Lee University, says: "He was a richly endowed man—first, with that capacity and that resistless bent toward the work in which he attained his great distinction that made it a perennial delight to him; but he was scarcely less richly endowed in his more unpretending and large human sympathies, and it was this latter endowment that distinguished him as a citizen and as a historian.

"As a citizen he was full of patriotic, American enthusiasm. He understood, as all must understand who look with seriousness upon the great problems that confront a free people and who measure the difficulties of those problems—he understood that at least one preparation for the discharge of the duties of American citizenship was the general education of the people, and so he advocated, as far as possible, bringing down to the reach of all the people, not only the opportunities, but the attractions and the incitements to intellectual living.

"Dr. Goode, with the quick and warm sympathies of the man and of the historian, seems to have felt that he could do no greater service to the people of his day and generation and to his country than in the most attractive and concrete way, if I may so express it, to lead the young men of this country to a study of the history of the past—to the deeds and the writings of the great men to whom we owe the foundation and the perpetuation of our institutions."

He was greatly interested in the establishment of a National University, and in 1891 read a paper in Philadelphia, afterwards printed in the magazine "Lend a Hand," edited by Edward Everett Hale, entitled "Washington's University the Nation's Debt of Honor." In this article he computed that the bequest of Washington to the United States for a National University would, at compound interest, amount, in 1892, to four million one hundred thousand dollars, and he proposed that the National Government should restore this sum as the nucleus of the endowment for the National University. He acted as secretary of the executive committee, of which the Chief Justice was chairman, which was laboring to this end, and spared no effort to bring it to a successful conclusion.

Another project in which he was interested and for which he labored was a movement to fully open French universities to American students. His interest was excited in this movement because he thought that American science was becoming one-sided, owing to the fact that all of the students who went abroad visited German universities. Of the American committee, which, in coöperation with the French committee, had this matter in charge, Dr. Goode was the secretary, and he had the satisfaction of seeing this project brought to a successful issue before his death.

He had a strong interest in literature, and wrote in an excellent English style—clear, direct, and unpretentious. I have never met a mind in touch with more far-away and disconnected points than his, nor one of the same breadth and variety of writing, outside of the range of his own specialty. He had fine æsthetic tastes, and derived keen enjoyment from everything that was beautiful in nature or in art. He knew all natural sights and sounds, and recognized the note of every bird. He knew good pictures and good prints, was familiar with all the processes of graphic arts, and a good judge of them, both on the technical and the artistic side. He loved a beautifully printed book and an artistic binding. All these tastes he utilized in the publications which he wrote or edited. The work which he had in hand at the time of his death and to which he devoted so much loving care, the History of the First Half Century of the Smithsonian Institution, he aimed to make the expression of all these tastes. To no writing which he ever did, did he bring a higher literary expression than to the pages which he prepared for this book. He was at infinite trouble in discussing such matters as the form of the page, the style of the type, the quality of the paper, the initial letters, the head lines and illustrations, and the binding, and when he discussed any of these points with the expert craftsmen his knowledge of the details was as full as their own.

In spite of ill health and suffering, his overwrought, nervous system and his occasional severe mental depression, he never allowed himself to take a cynical view of human nature. He was a man who loved his fellow-men, and to whom that love was repaid with a warmth to a degree rare in this day. He made all other men's concerns his own. He sent notes and suggestions to hundreds of scientific men, whose work profited thereby, and in the large circle of friends he had, scarcely one did not at one time or other come to Mr. Goode for advice and sympathy upon his own private affairs. He was an intensely loyal American patriot, ever careful that nothing should be said or done that should in any way reflect upon his country. He was especially devoted to Virginia and never happier than when he could spend a few days on her soil, looking over a historic house or copying some of the records which he hoped to turn to advantage in his historical studies.

"He is remembered," says Dr. Dall, "as one never weary of well-doing; who reached the heights, though ever aiming higher; whose example stimulated and whose history will prove a lasting inspiration."

"As a public-spirited naturalist," says Professor Osborn, "he leaves us a tender memory and a noble example, which helps us and will help many coming men into the higher conception of duty in the service and promotion of the truth. We cannot forget his smile nor his arm passing through the arm of his friend."

I have never known a more perfectly sincere and loyal character than Dr. Goode's, or a man who, with better judgment of other men or greater ability in molding their purposes to his own, used these powers to such uniformly disinterested ends, so that he could maintain the discipline of a great establishment like the National Museum while still retaining the personal affection of every subordinate.

I have scarcely alluded to his family life, for of his home we are not to speak here, further than to say that he was eminently a domestic man, finding the highest joys that life brought him with his family and children.

He has gone; and on the road where we are all going there has not preceded us a man who lived more for others, a truer man, a more loyal friend.

MEMOIR

OF

JOSIAH PARSONS COOKE.

1827-1894.

BY

CHARLES L. JACKSON.

PREPARED FOR THE NATIONAL ACADEMY.

BIOGRAPHICAL MEMOIR OF JOSIAH PARSONS COOKE.

Josiah Parsons Cooke, the son of Josiah Parsons Cooke, a successful lawyer, and Mary (Pratt) Cooke, was born in Boston October 12, 1827. He was educated at the Boston Latin School and Harvard College, from which he graduated in 1848, and after a year of travel in Europe was appointed tutor in mathematics in Harvard College in 1849. In 1850 he became Erving Professor of Chemistry and Mineralogy, a position which he held for the remainder of his life.

Cooke's equipment for the duties of his new place was almost entirely the result of his own exertions. A course of lectures by the elder Silliman first aroused his enthusiasm for chemistry and led him in early boyhood to fit up a laboratory in his father's house, where he attacked the science by experiment with such good results that even when he came to college he had a working knowledge of the subject. At Cambridge he continued these studies essentially alone, as the chemical teaching of the college during his four years of residence was confined to five or six rather disjointed and fragmentary lectures. Immediately after appointment to his professorship he supplemented these meager preparations by obtaining a leave of absence for eight months, which were spent in Europe buying apparatus and material and attending lectures by Regnault and Dumas. These formed the only instruction in chemistry he had received which could even claim to be systematic; yet with this slender outfit, aided by barely a year and a half of experience as a teacher, in 1851, at the age of 24, he found himself confronted with problems which would have taxed the abilities of an old, experienced, and fully educated professor. Chemical teaching in Harvard College had become extinct and must be reëstablished. The college was wedded to methods of teaching excellent for classics and mathematics, but entirely unfit for a subject like chemistry. These must be replaced by better methods, many of which were still to be invented. Finally he was called upon to take a prominent share in the great battle to introduce science into the college course on an equality with the humanities.

The zeal with which he threw himself into these tasks led to substantial results much more quickly than could have been expected. After only seven years he had succeeded in introducing required courses of chemistry into the sophomore and junior years. These, however, were only lecture and text-book courses; so that really a much more important advance consisted in the fact that he had also induced the Faculty of the College to accept an elective course in qualitative analysis, to be taught in the laboratory by the experimental method. It is noteworthy that from the very beginning of his career Cooke was an ardent adherent of the laboratory method of teaching chemistry invented not many years earlier by Liebig. This seems at first sight a strange breadth of view in a self-taught chemist, but, as he was fond of saying, the fact that he had taught himself chemistry by his own experiments showed him the value of this method for other students. But this was not all; a large building, Boylston Hall, had been built for the use of chemistry and comparative anatomy with money a large part of which had been raised by his exertions.

After this brilliant beginning the progress was continuous, until at the time of his death there were sixteen courses in chemistry and mineralogy, chosen by three hundred and fifteen students and taught by three professors, three instructors, and eight assistants. Boylston Hall was devoted exclusively to chemistry, and the Mineralogical Department was established in a section of the University Museum, also built through his exertions, where was exhibited the rich mineralogical collection created by him.

Cooke's scientific activity began even during his first struggles for the recognition of chemistry by the college, as in 1854 he published a paper on the numerical relation of the atomic weights, in which the periodic system of classification was foreshadowed, vaguely and imperfectly, it is true, but as fully as could be expected at that early day. In the same year his first large experimental research appeared, "On the alloys of zinc and antimony." Some small papers on spectroscopic, crystallographic, and analytical subjects bring us to his striking discovery of danalite and other new minerals from Rockport in 1866, and an extended research, both analytical and crystallographic, on the vermiculites and chlorites a few years later.

In 1873 he published the first of his most important series of researches, those on atomic weights, beginning with the vexed question in regard to that of antimony. From the first he saw that the great danger in such researches lies not in the accidental, but in the constant errors, and throughout he devoted himself to the study of these constant errors with the utmost patience, perseverance, and sagacity, and a skill in manipulation little short of marvelous, when it is remembered that his only instruction in this art had been derived from his assistants, who had studied in foreign laboratories, and also that a muscular affection rendered his hand so tremulous that it seemed at first sight impossible he could do chemical work of any sort. The result was a series of papers in which he established the atomic weight of antimony to the satisfaction of the whole chemical world. In connection with this work he made a careful study of some of the compounds of antimony with the halogens, in which, by the use of crystallographic methods, he succeeded in giving a probable explanation of the dimorphism of antimonious iodide.

The last of these researches was a careful redetermination of the relation between the atomic weights of oxygen and hydrogen. To this fundamental investigation he brought the same qualities which had helped him to his success with antimony. The experimental difficulties were even greater, but one by one they were overcome, and he was able to publish sixteen successive determinations showing a wonderfully close agreement, but, as Lord Rayleigh almost immediately pointed out, these results contained one of his old enemies, a constant error, due to the contraction of the glass globes when exhausted in order to weigh them empty. Cooke's last paper contained an ingenious method for avoiding this error by determining the tare of the globes without exhausting them.

His achievements in education and research did not, however, exhaust his tireless activity. He was a voluminous writer. In addition to the forty-one papers on his researches, he published thirty-two on other subjects, generally relating to chemistry, and eight books, ranging from such widely used text-books as the

Chemical Philosophy and New Chemistry to works on the relation of religion and science, and an interesting volume of essays.

He was also a brilliant and instructive popular lecturer, and has enriched our stock of lecture apparatus with many excellent contrivances, notably his arrangement for the projection of spectra, his form of the lecture-table eudiometer, and the vertical lantern.

His varied achievements obtained frequent recognition. In 1872 he was elected a member of the National Academy of Sciences, and almost at the beginning of his career he became a fellow of the American Academy of Arts and Sciences, of which he was successively librarian, corresponding secretary, and president. He was also a member of the Royal Institution and an honorary member of the London Chemical Society. In 1877 he was made an associate editor of the American Journal of Science. In 1882 he received the honorary degree of Doctor of Laws from the University of Cambridge, in England, and in 1889 from Harvard University.

In 1860 he married Mary Hinckley Huntington, of Lowell, who survives him. His death occurred in Newport, September 3, 1894.

I cannot sum up his character better than by quoting the words of his colleague, Professor H. B. Hill: "As an investigator, Professor Cooke was clear in thought, persevering amid difficulties, fertile in expedients, impatient of dogma, and to the end he retained the keen curiosity and enthusiasm of his earlier days."

A LIST OF THE MORE IMPORTANT PUBLICATIONS OF JOSIAH PARSONS COOKE.

Books.

1857. Chemical Problems and Reactions.
1860. Elements of Chemical Physics. New editions in 1866 and 1877.
1864. Religion and Chemistry, or Proofs of God's Plan in the Atmosphere and its Elements. New edition in 1880.
1868. Principles of Chemical Philosophy. New editions in 1870, 1875, and revised edition in 1881.
1874. The New Chemistry. New editions in 1876, 1877, 1884, and 1888. Also translations in many languages.
1881. Scientific Culture and Other Essays.

1888. The Credentials of Science the Warrant of Faith. New edition in 1893.
1891. Laboratory Practice. A Series of Experiments on the Fundamental Principles of Chemistry.

*Papers on His Original Investigations.**

1852. Description of a Crystal of Rhombic Arsenic. *Proc. Am. Acad.*, iii, 86.
1852. Octahedral Crystals of Arsenic. *Proc. Am. Acad.*, iii, 204.
1854. The Relation between the Atomic Weights. *Mem. Am. Acad.*, new series, v; *Am. Jour. Sci.* (2), xvii, 387.
1854. On Two New Crystalline Compounds of Zinc and Antimony. *Am. Jour. Sci.* (2), xviii, 229.
1854. On a New Filtering Apparatus. *Am. Jour. Sci.* (2), xviii, 127.
1855. On the Law of Definite Proportions in the Compounds of Zinc and Antimony. *Am. Jour. Sci.* (2), xx, 222.
1860. Crystalline Form not Necessarily an Indication of Definite Chemical Composition. *Am. Jour. Sci.* (2), xxx, 194; *Phil. Mag.*, xix, 405.
1861. On the Dimorphism of Arsenic, Antimony, and Zinc. *Am. Jour. Sci.* (2), xxxi, 191.
1862. On the Spectroscope. *Am. Jour. Sci.* (2), xxxiv, 299.
1863. On the Cleavage of Galena. *Am. Jour. Sci.* (2), xxxv, 126.
1863. An Improved Spectroscope. *Am. Jour. Sci.* (2), xxxvi, 266.
1863. Crystallographic Examination of Childrenite. *Am. Jour. Sci.* (2), xxxvi, 257.
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1865. On a Spectroscope with Many Prisms. *Am. Jour. Sci.* (2), xl, 305.
1865. On the Projection of the Spectra of the Metals. *Am. Jour. Sci.* (2), xl, 243.
1866. On the Aqueous Lines of the Solar Spectrum. *Am. Jour. Sci.* (2), xli, 17.
1866. Separation of Iron and Alumina. *Am. Jour. Sci.* (2), xlii, 78.
1866. Analysis of Danalite of Rockport. *Am. Jour. Sci.* (2), xlii, 73.
1867. On Cryophyllite. *Am. Jour. Sci.* (2), xliii, 217.
1867. On Certain Lecture Experiments. *Am. Jour. Sci.* (2), xliv, 189.
1867. Crystallographic Examination of Some American Chlorites. *Am. Jour. Sci.* (2), xliv, 201.
1867. A Method of Determining the Protoxide of Iron in Silicates not Soluble in the Ordinary Mineral Acids. *Am. Jour. Sci.* (2), xliv, 347.
1869. Atomic Ratio. *Am. Jour. Sci.* (2), xlvii, 386.

* Prepared by T. W. Richards.

1874. The Vermiculites. *Proc. Am. Acad.*, ix, 35.
1875. Melanosiderite. *Proc. Am. Acad.*, x, 451.
1875. On Two New Varieties of Vermiculites. With F. A. Gooch. *Proc. Am. Acad.*, x, 453.
1876. On a New Mode of Manipulating Hydric Sulphide. *Proc. Am. Acad.*, xii, 113.
1876. On the Process of Reverse Filtering. *Proc. Am. Acad.*, xii, 124.
1877. Revision of the Atomic Weights of Antimony. *Proc. Am. Acad.*, xiii, 1.
1877. Re-examination of Some of the Haloid Compounds of Antimony. *Proc. Am. Acad.*, xiii, 72.
1879. The Atomic Weight of Antimony. *Proc. Am. Acad.*, xv, 251.
1880. On Argento antimonious Tartrate. *Proc. Am. Acad.*, xix, 393.
1880. On the Oxidation of Hydrochloric Acid Solutions of Antimony in the Atmosphere. *Am. Jour. Sci.* (3), xix, 464.
1881. On the Solubility of Chloride of Silver in Water. *Am. Jour. Sci.* (3), xxi, 220.
1881. Additional Experiments on the Atomic Weight of Antimony. *Proc. Am. Acad.*, xvii, 1.
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1887. The Relative Values of the Atomic Weights of Oxygen and Hydrogen. With T. W. Richards. *Proc. Am. Acad.*, xxiii, 149.
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1889. On a New Method of Determining Gas Densities. *Proc. Am. Acad.*, xxiv, 202.

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1865. On the Heat of Friction. *Proc. Am. Acad.*, vi.
1871. Memoir of Thomas Graham. *Am. Jour. Sci.*
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1874. The Nobility of Knowledge. An Address Delivered before the Free Institute of Worcester. *Pop. Sci. Month.*, v, 610.
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1878. The Radiometer: a Fresh Evidence of a Molecular Universe. *Pop. Sci. Month.*, xiii, 1. Also *Am. Jour. Sci.* (3), xiv, 231.
1878. Chemical Philosophy. *Am. Jour. Sci.* (3), xv, 211.
1880. In Memoriam Josiah Parsons Cooke.
1880. Notice of Berthelot's Thermo-Chemistry. *Am. Jour. Sci.* (3), xix, 261.
1881. Memoir of William Hallowes Miller. *Proc. Am. Acad.*, xvi, 461.
1881. Notice of the Investigation of Dr. J. W. Brühl on the Relations between Molecular Structure of Organic Compounds and their Refractive Power. *Am. Jour. Sci.* (3), xxi, 70.
1881. Notice of Julius Thomsen's Thermo-chemical Investigation of the Molecular Structure of Hydrocarbon Compounds. *Am. Jour. Sci.* (3), xxi, 88.
1883. The Greek Question. *Pop. Sci. Month.*, xxiv, 1.
1883. Memoir of John Bacon. *Proc. Am. Acad.*, xviii, 419.
1883. Memoir of William Barton Rogers. *Ibidem*, 428.
1884. Memoir of J. B. A. Dumas. *Proc. Am. Acad.*, xix, 545.
1884. Memoir of C. A. Wurtz. *Ibidem*, 568.
1884. Further Remarks on the Greek Question. *Pop. Sci. Month.*
1885. Memoir of Benjamin Silliman. *Proc. Am. Acad.*, xx, 523.
1886. Descriptive List of Experiments for Use in Chemistry B.
1886. The New Requisitions for Admission at Harvard College. *Pop. Sci. Month.*, xxx, 195.
1889. The Chemical Elements. History of the Conception which this Term Involves. *Pop. Sci. Month.*, xxxiv, 733.
1889. Address at the Commencement Dinner.
1889. Concluding Address to the Freshman Class of Harvard College.
1890. Report of the Director of the Chemical Laboratory of Harvard College. Presented to the Visiting Committee of the Overseers.
1890. A Plea for Liberal Culture.
1892. The Value and Limitations of Laboratory Practice in a Scheme of Liberal Education.
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Also many Reviews and Reports, including Annual Reports as Director of the Chemical Laboratory during many years.

MEMOIR

OF

WILLIAM AUGUSTUS ROGERS.

1832–1898.

BY

EDWARD W. MORLEY.

READ BEFORE THE NATIONAL ACADEMY, NOVEMBER, 1899.

BIOGRAPHICAL MEMOIR OF WILLIAM AUGUSTUS ROGERS.

WILLIAM AUGUSTUS ROGERS was born in 1832, at Waterford, a small village near New London, Connecticut. His father was David Potter Rogers (1808–1882), who in 1830 married Mary Ann Rogers (1808–1892). He was master of a fishing vessel and afterward a farmer. It is said of him that he was the first in his district to use a chain cable for the anchor of his vessel, in spite of predictions of disaster. David Rogers traced his descent from James Rogers, born in England in 1615, who came to this country in 1635 and died here in 1688. He made his home in Stratford, Connecticut, and married Elizabeth, daughter of Samuel Rowland; he lived afterward in Milford, and in 1656 or 1657 he removed to New London, in the same State. James Rogers was a descendant of the John Rogers who was one of the compilers of the first authorized English Bible, and who was burned at Smithfield, under Queen Mary, in 1555. He brought to this country a Bible, which is still preserved in the library of Alfred University, which, it is claimed, is the Bible used by John Rogers, the ancestor just named.

Professor Rogers had two sisters, both younger than himself. Julia Maria survived him a short time; Cynthia died in 1843. In 1857 he married Rebecca Jane Titsworth, third child of Isaac D. Titsworth. She was the only daughter in a family of eight children. The family lived at Shiloh, New Jersey, and afterward at Dunellen, in the same State. The marriage was a fortunate one, Mrs. Rogers being the possessor of a fine appearance, great strength of character, a pleasant temperament, and sound, good sense. She has been somewhat concerned in the management of the weekly newspaper which is the organ of the religious denomination to which they belonged. Under the supervision of Dr. Rogers, she has done much of the computation required in reducing his astronomical observations and in preparing them for the press. They have had three sons, of whom two are living.

Frederick Tuthill Rogers was born in 1859, received the degree of bachelor of arts from Union College in 1880, that of doctor of medicine from the University of the City of New York in 1882, and is now established in practice in Providence, Rhode Island. Allerton Titsworth Rogers was born in 1863 and died in 1864. During his whole life his father was absent. Arthur Kenyon Rogers was born in 1868, received his baccalaureate degree from Colby University in 1890, and that of doctor of philosophy from the University of Chicago in 1899. It may be worth noting that a book on the higher criticism of the New Testament, which he wrote partly while an undergraduate and partly in the first year after his graduation from Colby University, was so well conceived and written as to have been issued from the press of a leading publisher in New York.

William Augustus Rogers began his studies in 1846 in De Ruyter Institute, at De Ruyter, New York, and prepared for college at Alfred Academy, in the same State. After teaching in a school in New Market, New Jersey, he entered the freshman class of Brown University in February, 1854. He taught in Union Academy at Shiloh, New Jersey, during the academic year 1854–1855, and was graduated with the degree of master of arts with his class in 1857. After this date Brown University conformed to the practice of other American colleges by giving not the degree of master of arts, but that of bachelor of arts after four years of undergraduate study. That he was a good scholar was certified by his election to membership in the Phi Beta Kappa society.

Immediately after taking his degree he was appointed instructor in mathematics at Alfred Academy; in 1859 he became professor of mathematics in Alfred University. He was absent for a year as a special student of astronomy in the Observatory of Harvard College, and afterward was a student and assistant in the same observatory for six months. He entered the navy in 1864, serving for fourteen months, or to the close of the war. In 1865 he built Alfred Observatory and equipped it with a clock, a chronograph, a nine-inch equatorial, and some other instruments. In 1866 he was made professor of industrial mechanics, as well as of mathematics, and, soon after, he spent nearly a year in the study of theoretical and applied mechanics at Sheffield Scientific School.

In 1870 he resigned the professorship at Alfred and was appointed assistant in the Observatory of Harvard College; in 1877 he was made assistant professor of astronomy in the observatory. In 1886 he resigned this position and became professor of physics and astronomy in Colby University, at Waterville, Maine. In 1889 he built the Shannon Physical Laboratory on the campus of Colby University. This building had special features making it better adapted to the comparison of standards of length than any other laboratory in the country. The equal-temperature room on its first floor was especially noteworthy.

The professorship of physics and astronomy at Colby University was held by Dr. Rogers at the time of his death; his resignation would have taken effect if he had lived another month, and he would then have become professor of physics at Alfred University. A physical laboratory had been built there under his supervision, and Dr. Rogers had donated for its equipment most of the apparatus which he had accumulated during his career, to the estimated value of ten thousand dollars.

Dr. Rogers' earlier papers treated of astronomical matters; mention of his astronomical work does not fall within the scope of this memorial. Before 1870 his opportunities for research were slender, but after that time his publications were frequent. When seven or eight astronomical papers had appeared he read his first paper on a physical subject, and, after this, his thoughts were drawn more and more to the consideration of physical problems. It is interesting to note that these problems were nearly all developments from this first physical paper.

It tells how he sought unsuccessfully for spider lines suitable for the meridian circle of the Observatory of Harvard College. He then attempted the production of lines of the desired quality and size by ruling them on glass. After some trouble and study of conditions, this was accomplished by etching the glass with hydrofluoric acid. He attained such skill in producing lines of suitable quality that he was employed to furnish expeditions, sent out from this country to observe the transit of Venus in 1882, with the ruled plates needed for certain photographic observations.

In supplying this practical want, Rogers became interested in a mechanical problem to which he gave all the spare time of three years, and which drew in its train nearly all the labors of the rest of his life. Nobert's well-known test-plates exhibit lines of great delicacy, uniformity, and distinctness. Rogers desired to learn the nature of the manipulation employed, and to attain some degree of skill in it. The solution of the problem consists of two parts: First, of the operation of moving the plate over given equal spaces; and, secondly, of the production on it of lines of various degrees of fineness. He constructed a machine in which a screw of eight inches in length could move a plate-carrier on parallel ways. Rogers did not provide the head of this screw with the teeth of a ratchet in order to turn the screw by small equal fractions of a revolution, since the spaces moved over would, in case a ratchet wheel were employed, be limited to the possible combinations of the number of teeth originally cut, and would also be affected with the errors of the gear-cutter used. He accordingly invented his magnetic clamp, in which the head of the screw is cylindrical, and is carried forward by a pivoted arm, to which it held fast during motion in one direction, while it is released during the motion of the arm in the reverse direction. When this screw and its mounting were completed, he studied the periodic errors of the screw. By a great expenditure of time and patience, these errors were made very small. Then came a long study of the form and position to be given the ruling diamond. He made a machine for grinding diamond points, and succeeded in making good cutting edges, both of Brazilian diamonds and of the so-called black diamonds, the latter giving the better results. Grinding a black diamond to a cutting edge took from five to ten days. With this ruling machine Rogers ruled plates showing fine lines like those of Nobert's test-plates. Up to eighty thousand lines to the inch, the lines could be well and accurately counted. The lines from eighty thousand to one hundred and twenty thousand to the inch were nearly as distinct as those of Nobert, but scarcely so smooth and uniform.

The skill in ruling which Rogers attained in this study he did not utilize in making fine rulings to be used as test-objects for the microscope. He thought it better to confine his attention to another most important problem. This problem consisted of three parts: First, to obtain authoritative copies of the imperial yard and of the meter *des Archives* at the temperatures at which they are standard, and to subdivide them into aliquot parts and obtain accurate micrometric standards; secondly, to compare the yard and the meter so as to obtain their ratio with increased precision; and, thirdly, to produce accurately spaced diffraction gratings the distance of whose lines should be accurately determined.

For the construction of diffraction gratings and of micrometric standards, Rogers constructed a second ruling machine, on a design much like that of the first machine, but with certain improvements. This was made at the works of the American Watch Company, at Waltham, Massachusetts. At first, a screw of four inches in working length was made; this screw did not effect any improvement in the performances of gratings ruled with it. This failure was thought to be due to the vibrations to which the machine was subjected, during its construction, by its position in a large factory, and a longer screw was attempted. A screw of half a meter in length was finally made by the artifice of cutting threads an inch and three-quarters long upon ferrules, using always the same part of the master screw, and then placing these on a cylindrical shaft so as to form a continuous screw of the desired length. Whitworth abandoned this method, but Ballou, who made the screw for this machine, seems to have overcome some of the difficulties which Whitworth met, and the screw was found to be practically perfect for a working length of twenty inches. With this apparatus Rogers ruled micrometric standards and test-plates with great accuracy. For such uses, where the lines needed were short, the machine was practically perfect. When it was used to rule the long lines needed on diffraction gratings, a difficulty was encountered, due to the fact that the motions of the ruling diamond in cutting the line and of the screw in making the forward motion overlapped each other. Some little reconstruction of details would perhaps have removed the difficulty; but, before any attempt was made to do this, Rowland's success with his apparatus for ruling diffraction gratings led Rogers to limit his aims to the other parts of his original problem.

The magnetic clamp which Rogers invented for use in his ruling engine was afterward utilized for other purposes, especially in constructing dividing engines for straight lines and for circles. He exhibited a dividing engine for circles at Chicago in 1894, and furnished others to various physical laboratories. He described one for straight lines in an article which he wrote for Johnson's Cyclopedia on ruling machines.

At some time before 1878 Rogers had begun an investigation which was important, both in its character and results, and also in the amount and kind of labor required for its successful completion. The relation between the yard and the meter had been determined by Kater, Baily, Clarke, Chisholm, and Hassler; but in all their observations copies of the yard had been compared with copies of the meter, and the errors of the copies were not sufficiently well known. The uncertainty in the determination of the relation could scarcely be deemed less than the one-thousandth part of an inch, and Rogers desired to make a comparison which should be much more accurate. The experience gained in his studies of micrometric standards had well fitted him for the work. Such a labor called for the possession of authoritative copies of the imperial yard and of the prototype meter. The Rumford committee of the American Academy of Arts and Sciences was interested in a plan for "obtaining authoritative copies of the revised original standards of the French meter and kilogramme." Partly in the interests of this committee, Rogers visited London and Paris. He took with him, for comparison with the imperial yard, a steel yard, and for comparison with the meter, a meter traced upon a bar of pure silver inlaid with laminæ of gold and of platinum. Through the kindness of Mr. Chaney, the warden of the English national standards, Rogers secured comparisons of his steel yard with the imperial yard at temperatures ranging from 50° to 68° F. At Paris Professor Tresca was engaged in the operation of constructing prototype meters, and Rogers was therefore unable to obtain comparisons of his silver bar with the meter *des Archives;* but Tresca did him good service by presenting him with a meter traced on platinum surfaces inlaid in a bar of pure copper of the same form as the platinum prototypes. On the 4th of February, 1880, this bar was placed on the comparer, with the working standard of the Conservatoire. At two o'clock in the morning of February 6 the transfer was made by Tresca, and the comparison of this with the working line meter of the Conservatoire was at once commenced by Tresca and Rogers, and continued through the following day and night.

Rogers now hoped that he was prepared to compare the yard and the meter, but it was soon found that the copper meter and the steel yard were not to be easily compared, and he therefore constructed a brass yard of the same shape, size, and weight as the imperial standard. This was compared with his own steel standard, and also with the standard of the United States Coast and Geodetic Survey. It may be said that, while the comparisons just mentioned were the basis of Rogers' earlier work in metrology, he afterward took occasion to fortify his values by many other comparisons and cross-comparisons, which need not be further described.

In the work thus begun an immense number of comparisons of length were required. For such comparisons two methods are available: In one, two micrometers are placed at a fixed distance; in the other, one micrometer is moved over a fixed distance. In the first method, two micrometers being fixed at a proper distance, one of the lengths to be compared is placed under them, and then the other; but this method cannot be applied to lengths less than the diameter of the micrometer and its mounting. For such lengths a micrometer moving between two stops may be employed. The stops are so adjusted that the space described by the micrometer between its two limits is equal to the length to be compared. One bar is then placed so that the two positions of the micrometer coincide with the two ends of the bar; the other is treated in the same way, and the comparison has been accomplished. By this method one apparatus and one homogeneous system of measurement serve for a length of a yard or meter, and also for all its subdivisions. Rogers preferred the second method, and constructed a comparer for lengths up to one meter. For ease of working it is necessary that the motion of the micrometer shall be very nearly in a straight line. In the first instrument made the ways on which the micrometer moved were not very different from those of a lathe bed. After some experience with this, a second was made, in which great pains were taken to meet the requirement just stated. Ways like those of a lathe, if carefully planed on a good and well adjusted planer, carefully examined and corrected locally, and so designed as not to suffer subsequent distortion, may be made to do excellent service; but a cylinder can be made straight, even with imperfect tools, and Rogers next constructed a comparer in which the carriage of the micrometer moved on two cylinders made with the greatest care and supported so as to eliminate their flexure. This comparer was called the Rogers-Bond comparer, Mr. Bond being the mechanical engineer who carried out the design of Mr. Rogers, while Pratt and Whitney constructed the machine. It was an instrument designed to do the best possible work, without regard to expense. Rogers afterward designed a much cheaper apparatus, intended to be used not only in refined investigations like his own, but also in ordinary and commercial operations in a machine shop, and much of his later work in metrology was accomplished on such modified forms of apparatus. The modifications involved that the apparatus should be finally adjusted by accurate local corrections for errors of its ways.

A room for the first comparer was inclosed in the basement of the Observatory of Harvard College and for the second in Harvard Hall. Soon after he removed to Colby University a new comparing-room was constructed in the physical laboratory erected for him, and this room was the most complete and convenient which had at that time been designed.

In these comparing-rooms and on these comparers Rogers made repeated comparisons of the yard and the meter. The method employed was elegant. A yard with convenient subdivisions and also a meter with convenient subdivisions were ruled on the same bar of metal. The error of this yard and the error of this meter were then determined by comparisons with his authoritative standards. Next, the errors of the subdivisions were determined by proper measurements. This is no small labor. When it had been accomplished it was possible to read off the length of the meter in inches and their fractions and also to read off the length of the yard in fractions of the meter. In this last operation the disturbing effects of changes of temperature were reduced to a minimum; the yard and the meter were both on the same bar at the same temperature, with the same temperature coefficient.

In the determination of a length nominally equal to a yard or a meter the effect of changes of temperature is of the greatest importance, and the means of eliminating it are difficult and tedious. Rogers was therefore compelled to make a most careful and laborious study of certain problems of thermometry. Having given a thermometer whose readings will determine the temperature of its own bulb to a hundredth of a degree, he had to learn in what conditions and with what degree of approximation this instrument will determine the temperature of another mass, such as a standard measure of length. If the thermometer and the measure of length could both be contained in a sufficient mass of liquid protected from evaporation, the temperature of the thermometer would determine the temperature of the measure of length. If the upper surface of the liquid is exposed to evaporation the upper layers of the liquid are not at the same temperature as lower layers, and Rogers determined the amount of this difference in certain conditions. Standards of length can seldom be employed while immersed in liquids, and Rogers abandoned attempts to immerse them for the sake of knowing more precisely their temperature, preferring to use his bars in his comparisons much as they would be used in ordinary measurements, the bar being surrounded only with air and the thermometers being placed in contact with it. How to observe so that the temperature of the bar could be determined from the temperature of the thermometer, Rogers learned thoroughly by an immense number of well-ordered series of observations. Commonly such observations involved the comparison of two bars, equal in length, but different in coefficient of expansion or in mass, or in form of cross-section, and at temperatures as widely different as could be secured. He made a long series of such comparisons in the open air during the coldest weather of a winter in Maine. Sometimes he read a great number of thermometers to determine a given temperature. He made some twenty-two thousand readings of thirty thermometers for such a purpose. These experiments gave him a manipulative command of the matter which few other men have attained, even if some of his minor conclusions on some points needed revision.

Rogers announced values obtained for the relation of the yard and the meter as early as the summer of 1880, and described further experiments at many times during the next fifteen years. It is not too much to say that his results reduced the uncertainty in the relation of the two standards to less than the fourth part of what it had been before, and that any important advance beyond the accuracy which he obtained has required the organization, the instrumental appliances, and the access to original standards which belong not to a single individual, but to a great institution, a government office, or an international bureau.

During the progress of the work just mentioned Rogers rendered many services to institutions, to societies, and to individuals. He was, for instance, a member of a national committee appointed by the coöperation of some fifteen societies, to prepare an authoritative centimeter with subdivisions, to serve as a standard for the preparation and the verification of micrometric scales. For this committee he made an elaborate report, founded on a multitude of observations, establishing the total length, and the values of the subdivisions, of the centimeter procured by the committee. He made standard bars, meters, or yards for Harvard, and Yale, and Columbia, and Princeton, and the Lick Observatory, and the United States Signal Service, and for various other institutions. These were more authoritative than could easily be secured elsewhere at the time when these were furnished. He prepared a combined yard and meter on the same bar for the Department of Standards of the British Board of Trade, to be used in an official investigation of the relation of the yard and the meter. He published an investigation of the standards of length furnished by the Société Génevoise. He made an elaborate determination of the length of eight of Rowland's gratings. He made an exhaustive report upon the standards of length used by Pratt and Whitney in their system of gauges. He superintended the construction of copies of many of the forms of apparatus used in his own investigations, which instruments are now in use in physical laboratories in this country and in Canada. He designed comparers capable of high precision, but cheap enough to be used as tools in the machine shop. Some of these could compare lengths even as great as one hundred inches, and some were small enough to be used on the workman's bench. He had a veritable passion for the utmost precision in measurement, a keen eye for opportunities for its advantageous use, the most unwearied and indomitable patience and perseverance, and clear insight into sources of error and means of avoiding it.

In all metrological studies the determinations of coefficients of expansions occupies a large place. Rogers' mind was full of this part of the subject, and when a new method of determining such coefficients was once explained in his presence he was eager to carry the suggestion into practice. The method involved the comparison by interferential methods of the length of a bar whose temperature varied from that of ice to that of steam with that of another bar which was kept in ice. He first constructed an apparatus for a preliminary trial in which the bars were not inclosed in the apparatus designed to keep them at a constant temperature, and in which only the optical principles of the method were to be tested. The result being satisfactory, he began the more difficult task of constructing an apparatus in which the same optical apparatus should be inclosed in an air-tight case, capable of being surrounded with ice, water, or steam. The requirement that the apparatus should be air-tight taxed severely the resources at hand and caused much delay. But such enthusiasm and energy as Rogers possessed finally triumphed; and one of the last important papers on any physical subject which he published contained a determination of the coefficient of expansion of a bar of Jessop's steel which he had carried out on the new apparatus. He had expected to do a great amount of work with this apparatus, and had spared no expense to adapt it to the intended labors.

When Roentgen's discovery was made public Rogers was one of those who interested themselves in the new field. He devised improvements in influence machines adapted to produce the so-called X-rays.

His experience in the construction of several ruling or dividing machines led him to take much interest in the problem of making a perfect screw. Before the American Society of Mechanical Engineers he read more than one paper on this subject. At the Waterville machine shop he constructed a large lathe screw which was practically perfect—that is, the screw acting with its correction plate would cut threads of the same pitch with very minute errors. On this lathe he constructed many precision screws, such as, for instance, those on the apparatus which he made for the measurement of photographs of stars at the Observatory of Harvard University.

Rogers was a hard-working man, a man of untiring activity. Nothing daunted his courage; difficulties which might well have made many a man down-hearted did not make him pause an instant. His chief pleasure was found in his work, but he enjoyed a game of tennis, which he played well. He greatly enjoyed a village game of base-ball, such as a game of stout men against thin men. Such a game he would play with enthusiasm, enjoying it thoroughly and contributing in a manly way to the enjoyment of others. He was unassuming, kindly, considerate in his intercourse with others; and also perfectly frank and outspoken. He was very conscientious, faithful to his convictions; and also genial. He would sometimes adhere to a point in the face of everybody, and then quietly submit when he was overruled. He was lion-hearted; he feared nothing and nobody. In Waterville he belonged to a civic league, of which he was an officer, and he went through the city presenting for signature a petition in favor of the enforcement of the so-called Maine liquor law by the local authorities. He enjoyed meeting with men who did not agree with him; enjoyed the humor of the situation; and he possessed so much good nature and good humor that, although he went, impartially, to those who were least likely to sign the petition, he rarely met with any discourteous rebuff. The feelings of his students toward him were very kindly.

He was an earnestly religious man in the evangelical sense. He belonged to that branch of the Baptist church which makes the seventh day of the week its day of rest. To the end of his life he scrupulously abstained from labor from sunset of Friday till sunset of Saturday. He was valued in the councils of his church, and contributed papers or articles to its conferences or its publications. He read papers or lectures on religious matters before his students, to which they listened with interest, as the expression of thorough conviction, supported by scholarship.

He worked to the last. For perhaps five years his friends could detect the progress of disease. In the summer of 1896 he attended the meeting of the American Association for the Advancement of Science for the last time, making an exhibit of an excellent straight-line dividing engine. The next summer he spent in an ocean voyage and a residence in an island climate; but *tabies dorsalis* cannot be checked. In the first month of 1898 its progress had been considerable. He continued to work against all advice. When he became unable to walk, his classes came to his house, and such labors were continued till fourteen days before death came. Its immediate cause was hypostatic pneumonia. He died on March 1, 1898.

He was elected a fellow of the American Academy of Arts and

Sciences at Boston in 1873. In 1880 Yale University conferred on him the honorary degree of Master of Arts, in recognition of his labors in preparing a volume of the Annals of the Observatory of Harvard College, containing his observations with the meridian circle. In 1881 he was elected an honorary fellow of the Royal Microscopical Society. In 1886 Alfred University, on the occasion of its semi-centennial, conferred on him the degree of Doctor of Philosophy. In 1892, thirty-five years after his graduation, Brown University conferred on him the degree of Doctor of Laws. He was vice-president of the American Microscopical Society in 1884, and its president in 1887. He was elected vice-president of the Section of Mathematics and Astronomy of the American Association for the Advancement of Science in 1882 to fill a vacancy, and regularly elected to the same office in 1883. He was elected vice-president of the Section of Physics in 1894. He was elected to membership in this Academy in 1885.

FREDERICK AUGUSTUS GENTH.

MEMOIR

OF

FREDERICK AUGUSTUS GENTH.

1820–1893.

BY

GEORGE F. BARKER.

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BIOGRAPHICAL MEMOIR OF FREDERICK AUGUSTUS GENTH.

The pure sciences are sometimes classified as independent and dependent sciences—*i. e.*, as resting upon data solely their own or upon data borrowed from other sciences. Mathematics, physics, and chemistry may be adduced as instances of the former class of sciences; astronomy, mineralogy, and biology as instances of the latter class. Without the fundamental principles of mathematics and physics, for example, neither mathematical nor physical astronomy is possible. Moreover, the properties of minerals are classified either by their chemical composition, by their crystalline form, or by their optical properties; so that mineralogy as a science is dependent mainly upon physics and chemistry, and to some extent also upon mathematics; so botany and zoölogy, except in so far as they are classificatory, are based upon the chemical and physical characteristics of the organisms they investigate and the forms they classify. Our eminent associate who is the subject of the present memoir took a high rank as an investigator in each of these divisions. His researches in chemistry are equaled in importance only by those which he made in mineralogy. Both were of the highest order, and secured for him a very prominent position among men of science.

FRIEDRICH AUGUST LUDWIG KARL WILHELM GENTH was born in the village of Waechtersbach, in Hesse, on the 17th of May, 1820. On his father's side his family was an old Hesse-Nassau family, living for the most part in the neighborhood of Wiesbaden. He was the son of Georg Friedrich, high warden of forests to Prince Issenbourg, and of Karoline Amalie Genth. His mother's maiden name was Freyin von Schwartzenau, and she was a native of Darmstadt.

From his earliest childhood young Genth was thoroughly trained by his father, especial care being taken in the cultivation of his powers of observation; so that very early in life he is reported to have taken a great interest in the natural sciences, and particularly in mineralogy, botany, and conchology. When he had attained his sixteenth year he entered the gymnasium at Hanau, at that time under the direction of Dr. Schuppius. There he remained until the 26th of September, 1839, when, in his nineteenth year, he was graduated from that institution fully prepared for his entrance into the university. The report which Dr. Schuppius made at this time calls especial attention to his great interest in natural history and geography, and speaks in the highest terms of his exceptional diligence and ability as a student during all the time while he was at the gymnasium.

Young Genth entered the University of Heidelberg on the 11th of November, 1839. He came into contact with men such as Bischoff in botany, Blum and Leonhard in geography, geology, and mineralogy, and Gmelin in chemistry, all eminent in the sciences which he had already cultivated, and whose instruction he highly valued. On the 21st of August, 1841, however, he left Heidelberg, and in the following November entered the University of Giessen, where he remained until April, 1843, studying chemistry under the direction of Fresenius, of Kopp, and especially of Liebig. The stimulating influence of such teachers as these left an impression upon his mind which largely contributed to determine his subsequent career. Unfortunately his health at this time gave way, and this, added to the pressure of other calls upon him, necessitated his retirement from active study for something more than a year. In May, 1844, he entered the University of Marburg, where he continued his chemical studies under Bunsen and his work in physics under Gerling. In the month of January, 1845, he presented his thesis to the faculty of the university and passed his examination for the degree of Doctor of Philosophy. The subject of his dissertation was "Beiträge zur Kenntniss des Kupferschieferhüttenprocesses, erläutert durch die Untersuchung der auf der Friedrichshütte bei Riechelsdorf gewonnenen Producte." He was soon thereafter appointed a privat-docent in the university, and subsequently chemical assistant to Professor Bunsen. This position he held about three years, resigning it in the spring of 1848. About the middle of that year he sailed for Baltimore and soon afterward established an analytical laboratory in Philadelphia. In the fall of 1849 he was offered the position of superintendent of the Washington (now

Silver Hill) mine, in Davidson county, North Carolina. This he accepted, giving up his laboratory in Philadelphia and removing to Davidson county. He remained in this position until August, 1850, when he resigned it and returned again to Philadelphia, reopening his analytical laboratory and devoting himself principally to research, to commercial analysis, and to the instruction of special students in chemistry. He continued here his work of investigation and of professional analysis until 1872, when, upon the death of Professor Wetherill, he was tendered the position of the professorship of chemistry in the University of Pennsylvania, then just entering upon the new era of prosperity consequent upon its removal to West Philadelphia. This position he accepted, though at considerable pecuniary sacrifice, continuing to hold it with credit to himself and satisfaction to his colleagues until the fall of 1888, when he severed his connection with the university and for the third time returned to his private laboratory and to his professional and research work.

It has already been mentioned that Dr. Genth, even at the outset of his career, owing without doubt to his father's early training, took a great interest in the natural sciences, especially geology. His earliest paper, published while he was yet a student in the University of Giessen, shows the influence upon his mind of Leonhard, with whom he had studied at Heidelberg. It was entitled " Binnenconchylien lebender Arten im Kalktuff von Ahlersbach," and appeared in *Leonhard & Bronn's Jahrbuch* for 1842. The same year he published a second geological paper, entitled "Alter verschiedener Zechsteine," and in 1848 two further similar papers, " Eocene Schichten mit Beschreibung der Petrefacten " and " Miocene Geognosis des Mainzer Beckens," all appearing in the *Jahrbuch.*

In Giessen, however, under the influence of Liebig, of Kopp, and of Fresenius, and particularly in Marburg, where he received his chemistry directly from Bunsen, his mind was turned strongly in the direction of chemical science, together with its associate science, mineralogy. Even before taking his doctor's degree in 1845 he published papers on " Prehnite, a Pseudomorph after Analcime," on the " Chemical Examination of Masopin, a New Gum Resin," and on the "Analyses of Various Refined Coppers." Soon after graduating he published two manuals, the first a "Tabular Review of the Most Important Reactions of Bases," and the second a similar one on the acids.

Dr. Genth's purely chemical papers number thirty-one in all. In 1845, in a letter to Liebig, he called his attention to an allotropic modification of nickelous oxide $NiO\beta$. He had noticed on certain disks of refined copper from Riechelsdorf, a layer of small, almost microscopic crystals, which at first he mistook for cuprous oxide. But, unlike this substance, they were left behind on dissolving the copper in nitric acid. Under a magnifier they were recognized as regular octahedrons. They were grayish black in color, giving a brownish streak. They were opake, were not magnetic, and possessed a metallic luster. They were quite brittle and had a hardness between calcite and fluorite, and a specific gravity of 5.745. They were insoluble in nitric, hydrochloric, and sulphuric acids in the cold, but dissolved in the latter acid on boiling. They were not altered by fusion with carbonates, but borax and phosphorus-salt dissolved them, giving a nickel bead. On fusing with acid potassium sulphate the solution gave on evaporation crystals of potassium nickel sulphate and reacted like nickelous oxide. On reduction with hydrogen, 5.5780 grams gave 4.3905 grams nickel, showing it to be a pure nickelous oxide. In 1853 he described in the *American Journal of Science* a similar compound of cobalt in iron-black brilliant microscopic octahedrons with a submetallic luster.

In 1848 Dr. Genth published in *Liebig's Annalen* a paper giving analyses of the lavas from Hecla which were collected by Bunsen in his journey to Iceland. This investigation is remarkable as the first ever made upon the products yielded by an active volcano with a view to determine whether those products agree with each other in composition at different eruptive periods. The lavas analyzed were those of Thjorsá, Háls, Efrahvolshraun, and that of 1845, named in the order of eruption. Besides these, an analysis of volcanic dust from the eruption of 1845 is given, the dust having been collected from a clean surface of snow. The Thjorsá lava consisted of a grayish-black mass filled with cavities containing, besides crystals of scapolite, a new mineral which he called thjorsaite. The Háls lava was found to resemble Laurent's wichtisite. The author finds (1) that these lavas differ from those of Vesuvius and Ætna, (*a*) in that they contain no material gelatinizing with hydrochloric acid, and (*b*) that they are insoluble in this acid, excepting traces of magnetite; (2) that they all contain a single essential constituent, forming substantially the entire mass, which has the same composition as wichtisite, and (3) that the variation from wichtisite of the elemental ratio is due to the presence of thjorsaite, chrysolite, orthoclase (?), and magnetic iron in different proportions.

In *Erdmann's Journal für praktische Chemie* for 1846 an elaborate paper was published by Dr. Genth on a "Chemical Examination of the Products obtained in the Metallurgy of Copper Schists," the special works studied being the Friedrichs plant at Riechelsdorf. This paper, which covers 48 pages, is substantially his inaugural dissertation at Marburg. The immediate occasion of the investigation was the sending to Professor Bunsen for analysis of various samples of Norwegian and Swedish refined copper, together with two specimens from the Riechelsdorf works, by the Kurfürstliche Ober-Berg und Salzwerks-Direction of Cassel. The examination of these coppers was given in charge to Dr. Genth, and the great differences observed in the content of nickel and silver in these specimens led him to undertake a more general investigation into the products of the Riechelsdorf plant. During this research he improved many analytical methods and devised some new ones. He observed that the precipitation of barium sulphate in presence of hydrochloric acid caused the precipitate to become granular; so that the filtrate was clear and not turbid, except in presence of acetates. He proposed methods for detecting minute quantities of nickel in presence of cobalt and for separating manganese from zinc by igniting the carbonates with access of air and subsequent extraction with dilute acetic acid. It was during this investigation that he discovered the allotropism of nickelous oxide already mentioned. The paper is divided into six sections. The first gives a general review of the Riechelsdorf process for working the copper schists. In the second the analytical methods which he employed are described. The third considers the Friedrich's products and gives their physical properties and chemical composition. The fourth gives the results of analyses of other coppers—Japanese, Avista, Norwegian, Gustav, Carlsburg, Dillenburg, and a cement copper from Westphalia. In the fifth is given a tabular statement of all the products which were analyzed, and the sixth states some chemico-technological conclusions. The value of this research was recognized by a letter of thanks from the direction, and was followed by some material changes in the processes used at the Friedrich works, due to the results of the analytical work which had been done.

In December, 1852, Dr. Genth read before the Academy of Natural Sciences a paper on a supposed new element which he had detected in certain small white grains associated with iridosmine and platinum from California. On treatment with hydrochloric acid two of the metallic particles began to dissolve with the evolution of hydrogen. They were at once removed, washed, and examined with a magnifier, when they were shown to be mixed with gold. In color they were between tin white and steel, were malleable, but harder than tin, and dissolved in nitric acid, yielding a crystalline salt. The solution gave a brown precipitate with hydrogen sulphide. Before the blow-pipe, on charcoal, the metal fused readily, but became soon covered with a black oxide. It gave no incrustation. With borax in the outer flame, it dissolved, giving a colorless bead, which became opalescent on cooling. While the new metal somewhat resembles tin, it is distinguished from it (1) by its complete solubility in nitric acid, (2) by its brown precipitate with hydrogen sulphide, and (3) by its not being readily oxidized into a white oxide before the blow-pipe.

But the chemical research by which Dr. Genth is best known is undoubtedly that on the ammonia-cobalt bases, which, as developed jointly with Dr. Wolcott Gibbs, was published as a monograph by the Smithsonian Institution.

Doctor Genth's original memoir was published in Philadelphia in 1851, in *Keller & Tiedemann's* "*Nordamerikanischer Monatsbericht für Natur und Heilkunde*," under the title "Vorläufige Notiz über Gepaarte Kobalt verbindungen." This paper contained the first distinct recognition of the existence of perfectly well-defined and crystallized salts of the ammonia-cobalt bases. Indeed, it would appear that no trace exists in any earlier publication of even the idea of such a class of compounds. The results given in the paper were first obtained by the author, in Marburg, in 1847, while chemical assistant to Professor Bunsen, during the latter's absence in Iceland. They were freely communicated verbally to others, and a suite of the salts obtained were deposited at the time in the Giessen laboratory. In this early memoir Dr. Genth describes two series of salts in which cobalt oxide, paired with ammonia, acts as a base. To prepare these bases ammonium chloride is added to a solution either of cobaltous chloride or sulphate, and the solution is saturated with ammonia. After standing four or five weeks in the air, and the excess of ammonia has evaporated, hydrochloric acid is added to acid reaction and the solution is boiled. After some time a crystalline heavy carmine-red powder is deposited, a further quantity of which is obtained by further evaporation of the solution. This carmine-red salt is with difficulty soluble in cold water, easily in boiling water. If no free acid is present, the aqueous solution is decomposed on boiling or even on long standing in the air. The presence of acetic or hydrochloric acid prevents this decomposition, and from this solution the pure salt can be obtained by crystallization. The crystals are small octahedrons, peach-blossom carmine-purple red to black in color. On analysis they gave the empirical formula $Co_2O_3(NH_4)_3$ Cl.; hence they must be considered the chloride of the paired compound $Co_2O_3(NH_4)_3$, which plays the part of a metal. From this chloride, by double decomposition, not only the base itself, but a beautiful series of salts may be obtained. The base is described in the paper, and also the carbonate, sulphate, nitrate, chromate, and molybdate, as well as the compounds formed with mercuric, stannic, and platinic chlorides. In the mother liquor from which the carmine-red compound was prepared an orange-yellow cobalt compound was obtained by further evaporation, it being more soluble than the red salt. Its crystals were rhombic or klinorhomboidal. The phosphate crystallizes in gold-yellow, brilliant needles. "Though the analyses here given were from necessity not sufficiently complete and extended to fix the constitution of the bases in question, yet the fact is indisputable that this memoir contained not merely the first announcement of the existence of ammonia-cobalt bases, but also a scarcely less accurate and complete description of two of these bases than any which has since appeared." The foregoing memoir was called by Dr. Genth a preliminary notice, but, since circumstances prevented a resumption and continuation of this subject, the field was entered by others. Claudet in 1851 described with some detail the properties of purpureo-cobalt chloride, and later in the same year Fremy communicated to the French Academy two preliminary notices, claiming as his own the discovery of a class of bases containing cobalt and ammonia produced by the oxidation of ammoniacal solutions of cobaltous salts, his complete memoir not appearing until the following year. He appears not to be aware that the two bases which he describes had been already described by Genth, in a manner but little less complete than his own, in a paper published two years before.

In the joint monograph of Gibbs and Genth, published by the Smithsonian Institution in 1856, the nomenclature of Fremy is substantially adopted, though somewhat modified. Instead of "roseocobaltiaque" and "luteocobaltiaque," as Fremy proposed, roseocobalt and luteocobalt are used for the two bases originally discovered by Genth; purpureocobalt for the base discovered by Claudet; xanthocobalt for that of Gibbs, and fuscocobalt for Fremy's base. The colors of these substances are referred to the chromatic scale of Chevreul, as suggested by Fremy, and the crystallographic measurements given were made by J. D. Dana. After describing the methods of analysis, the monograph goes on to state at length the mode of preparation and the properties of the salts of roseocobalt, purpureocobalt, luteocobalt, and xanthocobalt, together with the results of their analysis. It concludes with a theoretical discussion of the rational structure of these bases. Considering them as conjugated compounds of sesquioxide, sesquichloride, etc., of cobalt, the five or six equivalents of ammonia or of ammonia and nitrogen dioxide are viewed as forming the conjunct and serving to give to the sesqui-compound of cobalt the degree of stability which it possesses in this class of bodies. Hence the chloride of luteocobalt is written $\overset{\frown}{(NH_3)_6Co_2}.Cl_3$, employing the connecting circumflex as a symbol of conjugation, as suggested by Kolbe. Adopting this view, we have the following conjugate radicals, which we assume as existing in the ammonia-cobalt bases, precisely in the same sense in which we assume Co_2 as existing in the sesquichloride and the sesquioxide of cobalt:

Roseocobalt........	$\overset{\frown}{(NH_3)_5Co_2}$	Luteocobalt........	$\overset{\frown}{(NH_3)_6Co_2}$
Purpureocobalt.....	$\overset{\frown}{(NH_3)_5Co_2}$	Xanthocobalt...	$\overset{\frown}{NO_2(NH_3)_5Co_2}$

But while two of these bases are triacid bases, the other two are diacid, one of these, purpureocobalt, even forming acid compounds with four equivalents of acid. In order to explain this condition of things, the authors assume in these latter the existence of secondary radicals containing oxygen; these secondary radicals being in purpurecobalt $\widehat{(NH_3)_5Co_2}O$ and in xanthocobalt $NO_2(NH_3)_5Co_2O$. A tabular view is given of the rational formulas of all the salts examined upon the above assumption.

Thus roseocobalt chloride is................ $\widehat{(NH_3)_5Co_2}.Cl_3.H_2O$

purpureocobalt chloride .... $\widehat{(NH_3)_5Co_2}Cl.Cl_2$

luteocobalt chloride .... $\widehat{(NH_3)_6Co_2}.Cl_3$

xanthocobalt chloride............. ..$NO_2.\widehat{(NH_3)_5Co_2}O.Cl_2$

This elaborate and extended research has always stood among the finest chemical investigations ever made in this country. Several years were required to complete it, the analytical portion of the work being as difficult as it was protracted.

In 1858, also in conjunction with Dr. Gibbs, Dr. Genth published a preliminary notice of a new base containing osmium and the elements of ammonia. In consequence of their joint research on the ammonia-cobalt bases, the authors were led to investigate the production of analogous compounds with other metals. For this purpose they studied the action of the mixed nitrogen oxides upon ammoniacal solutions of the platinum metals, and discovered the fact that a well characterized base is formed by osmium with ammonia, the salts of which crystallize well. The chloride of this base is a yellow crystalline salt, which was first noticed by Fremy in 1844 and called osmiamide. The authors found, however, that the rational formula he assigned to it was erroneous, and that it is a true chloride, yielding a beautiful salt with platinic chloride and giving, on double decomposition with salts of silver, a well characterized sulphate, oxalate, nitrate, etc. The salts of this new base have a beautiful orange-yellow color, are nearly insoluble in cold water, but more soluble in hot. The solutions decompose easily, however, evolving osmic acid. The authors attribute to the chloride the formula $\widehat{(NH_3)_2OsO_2}.Cl$.

The chief chemical investigations of Dr. Genth, however, and those which will cause his work ever to be most highly valued, are the investigations which he made in connection with mineralogy. As early as 1842 he published a paper in *Leonhard & Bronn's Jahrbuch* on a pseudomorph of prehnite after analcime, and in 1848 he gave a mineralogical paper in *Liebig's Annalen*, containing analyses of baulite from Krabla, of phillipsite from Stempel, of chabasite from Annerode, of iron-mould from the Alte-Birke mine, and of speiss-cobalt from Riechelsdorf. In 1851 he announced in *Keller & Tiedemann's Monatsbericht* the discovery of traces of platinum in Lancaster county, Pennsylvania, of tetradymite in North Carolina, and of a magnetic pyrite, containing 2.9 per cent. of nickel, in the Gap mine of Lancaster county. This pyrite has since been made the basis of a considerable nickel industry. Later he described a mineral from Texas, Pennsylvania, which he considered to be a gymnite in which a part of the magnesia is replaced by the isomorphous nickelous oxide. To this mineral he gave the name nickel-gymnite; but Dana subsequently called it genthite.

A series of valuable papers entitled "Contributions to Mineralogy" were published by Dr. Genth from time to time for several years. These papers were fifty-four in number and contained descriptions of two hundred and fifteen mineral species, in most cases accompanied by analyses. Most of these appeared in the *American Journal of Science*, although some were published in the *Proceedings of the American Philosophical Society* and in other serials. In several of the later "Contributions" he was associated with Professor Penfield, who furnished the notes on crystallography. Besides these comprehensive papers, Dr. Genth was the author of twenty-three minor contributions to chemical mineralogy, many of which contained descriptions of new minerals. He was the discoverer of twenty-four new mineral species, all of which were so thoroughly individualized, both by chemical and by physical methods, that they took at once a position in the science which they have ever since maintained.

In 1854 he described a new meteoric iron from New Mexico, given him by Professor Henry, and labeled "native iron." On analysis it afforded: iron, 96.17; nickel, 3.07; cobalt, 0.42, and 0.57 of insoluble matter, consisting of iron, nickel, and titanium. This insoluble portion was a steel-colored powder in microscopic crystals. The next year he published the analysis of a fragment of one of the meteoric irons of Tucson, Mexico, presented to the Academy of Natural Sciences by Dr. Herrmann. This analysis showed the meteorite to consist of iron, copper, cobalt, nickel, chromium, alumina, magnesia, lime, soda, potash, phosphorus, and silica, together with a feldspathic mineral supposed to be labradorite. It agreed substantially with the analyses by J. L. Smith of a fragment cut from one of the huge masses in that region by Lieut. John G. Parke, U. S. Engineers. In 1886 he described a new meteorite from East Tennessee.

One of the most important and also one of the most extended of Dr. Genth's mineralogical investigations, however, was that made upon "Corundum, its alterations and associated minerals," the results of which were communicated to the American Philosophical Society in 1873. This paper occupies forty-six pages of the *Proceedings*. He had exhibited to the society, in the spring of 1871, several peculiar crystals of corundum, altered either wholly or partly into other mineral species. "Further chemical investigation of these crystals and of others similar to them gave results leading to conclusions which seemed to possess interest, not only for the chemist and mineralogist, but in connection with their paragenesis, to the geologist also." The largest deposits of corundum in the world are in a chromiferous serpentine or chrysolite formation and in the rocks adjoining thereto. Localities of this mineral have been developed all the way from Massachusetts to Alabama, and it will always be an interesting question by what agencies such enormous quantities of alumina could have been precipitated to form it. Especially so since by its subsequent alteration it has given rise to many of the most widely distributed minerals and rocks. The most important eastern corundum deposit is that at Chester, Massachusetts, discovered by C. T. Jackson and mineralogically described by C. U. Shepard and J. L. Smith. The deposit of this locality consists of crystalline corundum contained in a fine scaly chlorite, and of a peculiar mixture of granular and crystallized corundum with magnetite intermixed with more or less of a chloritic mineral. The deposit traverses two mountains for about four miles, having an average thickness of four feet, lying in a talcose slate and serpentine between gneiss and mica slate in the center of the Green Mountains. The gneiss itself contains no corundum; but the talcose rock has grains of emery, of corundum, and of magnetite distributed through it. The corundum occurs either in small brownish crystals or in very fine grains. Sapphire in pyramidal crystals is sometimes met with. Pinkish margarite, diaspore, and corundophilite invest frequently the corundum or emery, associated with tourmaline, cyanite, chloritoid, ilmenite, rulite, etc. At Litchfield, Connecticut, corundum is found in balls of cyanite associated with talc and diaspore. At Unionville, Chester county, Pennsylvania, crystals of corundum are frequently met with in the soil, large boulders of it being not unusual. The bed whence these came showed a mass of almost solid corundum thirty feet long, five to ten feet thick, and about fifteen feet deep. The corundum itself is granular in structure, brownish gray in color, and shows a gradual change into other minerals, among which Dr. Genth observed diaspore, gibbsite, damourite, margarite, soda-margarite, euphyllite, zoisite, tourmaline, chlorite, lesleyite, and pattersonite.

By far the most numerous localities of corundum, however, many of them of great scientific interest, occur in North Carolina, the most easterly locality being in Guilford county. Here the corundum is a true emery, being granular and mixed with magnetite and associated with a chloritic mineral. The corundum belt, which stretches, with occasional interruptions, southwesterly from Madison county, North Carolina, through Georgia into Tallapoosa county, Alabama, a distance of at least 250 miles, was discovered by the Rev. C. D. Smith. The first large mass of corundum was found in 1847, on the French Broad river, near Marshall, Madison county. It was dark blue in color and was associated with chlorite and margarite. In all probability it came from the great chrysolitic belt. Dr. Genth had already suggested that the chromiferous and nickeliferous serpentines and talc slates owe their existence to the decomposition of chrysolite rocks, an opinion proved later to be correct. The outcrop of the Culsagee mine, near Franklin, Macon county, North Carolina, extends over thirty acres, the strata which are there developed, according to C. U. Shepard, being (1) chrysolite rock mixed with anthophyllite, (2) micaceous rock, (3) a seam of chalcedony, (4) a stratum of chloritic rock (ripidolite), and (5) a similar layer through which the corundum is irregularly diffused. According to J. Willcox, the chlorite schist is much decomposed, even to a depth of fifty or sixty feet, the corundum itself falling easily into fragments. At right angles to the chlorite schist a vein of chlorite several feet wide was found, containing large crystals of corundum, which also fell readily into fragments. About twenty miles southwest of this mine is the so-called Cullakenee mine, the outcrop of the chrysolite rock here covering an area of about 300 acres. In many places corundum is found in boulders. The chrysolite contains the usual associates of serpentine, such as actinolite, picrolite, etc., and is already partly changed into serpentine. Near the middle of the chrysolite bed is an outcrop of a very peculiar rock resembling omphacite and consisting of green smaragdite, a white triclinic feldspar, and highly colored grains of ruby intermixed with cyanite and chromite in small quantities. The corundum here is generally of a grayish-white or pale ash-gray color, with specks of sapphire occasionally. Sometimes, however, it is of a beautiful pink color, associated with andesite, zoisite, margarite, hornblende, and rarely with chlorite, spinel, and tourmaline. Ten miles southeast of Cullakenee, corundum again occurs, and for five or six miles, extending into Georgia, it is often found associated with chlorite and probably smaragdite, the chrysolite lying between beds of hornblendic gneiss. The Georgia locality resembles that at Culsagee. Near Gainesville a very peculiar corundum occurs. It exists as a nucleus in irregular kidney-shaped masses of margarite or with a peculiar earthy mineral of a color between isabel and flesh red, frequently intersected by veins of a fine scaly or massive margarite. Quite similar to these occurrences of corundum are those of the Ural, as described by G. Rose, and of Asia Minor, as given by J. L. Smith.

After this general survey of the geological conditions attending the occurrence of corundum, Dr. Genth proceeds to discuss the minerals which are found to be associated with it.

I. *Spinel.*—Corundum altered into spinel occurs in many localities, the most interesting variety coming from Hindostan. The surface of the corundum crystals is rough, and to many of them reddish orthoclase and a dark mica are attached, showing their matrix to have been granite. Most of the crystals are from half an inch to two inches in size. Many are completely altered, but most of them show that the alteration began at the surface and has penetrated irregularly the crystals toward the center, leaving frequently a nucleus of brownish gray, cleavable corundum. The spinel, the result of this alteration, is black in color, has a granular crystalline structure and a vitreous to submetallic luster. Material from seven other localities is described and their analyses given. These show that the spinel is pseudomorphous after corundum, the specimens from Hindostan and a green spinel from Culsagee being mixtures of the spinel varieties pleonaste and hercynite, while the other spinels from Culsagee contain in addition an admixture of the variety picotite.

II. *Diaspore.*—Although this mineral has been observed in many places as the result of the hydration of corundum, it does not appear that a real pseudomorph has ever been met with. Though J. L. Smith notes that all the corundum he had examined contained from 0.68 to 3.74 per cent. of water, yet he was not able to detect diaspore. Dr. Genth suggests that it may be so minutely distributed through the corundum that even careful microscopic examination fails to detect it, as is the case sometimes with spinel. Diaspore is abundant and of rare beauty in Chester, Massachusetts. Dr. Isaac Lea found it at Unionville in beautiful crystals and J. C. Trautwine noticed it in cavities of massive corundum from the Culsagee mine.

III. *Beauxite.*—This aluminum hydrate, mixed with ferric hydrate and a hydrous aluminum silicate, and inclosing grains of corundum, occurs abundantly in the south of France. T. S. Hunt has suggested that since beauxite can be converted into corundum by intense heat, the same change may have taken place in this locality at ordinary temperatures. Dr. Genth, however, not knowing of a single instance of the production of corundum under these conditions, infers that the reaction must have been in the inverse direction, and that the beauxite has resulted from the hydration of the corundum, some grains of which still remain unconverted.

IV. *Gibbsite.*—This rare aluminum hydrate has been noticed only twice in contact with corundum—once in Asia Minor, by J. L. Smith, and once at Unionville, Pennsylvania, by T. F. Seal.

V. *Quartz.*—This mineral is mentioned by Sillem as occurring as a pseudomorph after corundum.

VI. *Opal.*—Dr. Genth observed the variety hyalite in connection with corundum and the minerals resulting from its alteration, first at Culsagee mine, where it occurs rarely in beautiful colorless and white botryoidal incrustations on foliated chlorite and on corundum, and again at Dudleyville, Alabama.

VII. *Smaragdite.*—The peculiar rock formed by a feldspathic mineral, supposed to be smaragdite, and grains of pink and even deep ruby corundum at the Cullakenee mine, has already been mentioned. The smaragdite grains are very indistinct in form, frequently showing an obtuse angle like that of an amphibole. Their color is emerald to grass green, passing into grayish green. An analysis by Chatard, in Dr. Genth's laboratory, gives an atomic ratio of 4 : 1 : 4, agreeing exactly with that of kokscharoffite. Other varieties of amphibole are in some localities associated with corundum and even penetrate its mass. A black or brownish black hornblende occurs in the andesite of Cullakenee and a dark-green variety, often associated with zoisite, is found with and in the corundum of the same locality.

VIII. *Zoisite.*—G. Rose had already observed zoisite as an associate of corundum in the Urals, and B. Silliman described it, under the name unionite, as occurring with corundum at Unionville, Pennsylvania. The best locality for it, however, is at the Cullakenee mine, in North Carolina, where it occurs, often in crystals, though generally in compact and columnar masses easily cleavable, and from grayish to greenish and brownish white in color. Many of the specimens show distinctly that it is the result of the alteration of corundum, the pink corundum being often surrounded by a thin coating of white zoisite. Analyses are given of the mineral from this locality for comparison with that of unionite, by G. J. Brush.

IX. *Feldspars.*—Of the many varieties of feldspar occurring with corundum, Dr. Genth enumerated (1) a white grayish and reddish variety of anorthite, called indianite by Bournon, as the matrix of corundum in the Carnatic, associated with cyanite and garnet; (2) a snow-white massive granular feldspar, observed in the Ural by G. Rose, who gave it the name of barsowite; (3) a snow-white or bluish-white cleavable feldspar, associated with hornblende at the Cullakenee locality, together with a granular and very compact variety, having crystals of corundum disseminated through it; (4) a fine-grained and very friable variety from Cullakenee, resembling the oligoclase from Chester, but containing hornblende crystals through it in place of biotite; (5) soda-oligoclase from Unionville, analyzed by

Smith and Brush and also by Chatard; (6) a yellowish white granular feldspar from Mineral Hill, Pennsylvania, containing crystals of corundum altered into fibrolite and other minerals; it appears to be an oligoclase; (7) indianite from Chester, Massachusetts, proved by Jackson to be granular oligoclase; and (8) a white granular feldspar found on the road from Unionville to Kennett Square, and determined as albite by Brush and Weld. It is frequently the matrix of gray corundum associated with euphyllite (?). As to the question whether the feldspars found in connection with corundum are the result of the alteration of this mineral, Dr. Genth concludes that many more observations will be needed in order to answer it positively; but from what he has already seen he believes that there are cases where feldspars have been formed from corundum. Perhaps, at the same time, a portion of the alumina recrystallized as corundum, and is thus found imbedded in the feldspathic matrix.

X. *Tourmaline.*—This mineral is associated with corundum at most of the localities already mentioned. At Unionville black tourmaline occurs in irregular masses of different sizes, in the corundum itself as well as in the masses resulting from its alteration. Dr. Isaac Lea mentions the occurrence of a crystal of transparent green tourmaline passing through the middle of a prism of diaspore, the whole enveloped by lamellar crystals of pearly emerylite (damourite, Genth). At the Culsagee mine the association of tourmaline with corundum is of special interest. There are masses of black tourmaline containing crystals of white and yellowish-white corundum disseminated through them, the particles of tourmaline being intermixed with the corundum crystals and *vice versa*, though on the whole the tourmaline looks more like the matrix of the corundum. One specimen from this mine which was examined by Dr. Genth is a pseudomorph of tourmaline after corundum, showing three planes of the hexagonal prism and portions of one pyramidal plane.

XI. *Fibrolite.*—For a long time this mineral has been known to accompany corundum both in Europe and Asia. The variety which was used by the Celts in the stone age was obtained in the neighborhood of Chavagnac and Curouze, in France, where it is associated with mica, cyanite, and red and blue corundum.

At Norwich, Connecticut, the small crystals of sapphire are completely surrounded by fibrolite. Analyses are given of the mineral from Mineral Hill.

XII. *Cyanite.*—This mineral is a very common associate of corundum, rolled masses of it occurring in Litchfield and Washington, Connecticut, containing corundum and diaspore. An interesting specimen from Newton, Connecticut, received from G. J. Brush, consists of irregularly arranged bladed masses of gray bluish-white and blue color, a white or yellowish-white micaceous mineral occurring where the blades meet, imbedded in which is diaspore. In one place, in immediate contact with the cyanite, is a rounded fragment of a slightly pink corundum.

The list of these associated minerals is continued as follows: XIII, Staurolite; XIV, Pyrophyllite; XV, Damourite; XVI, Ephesite (Lesleyite); XVII, Paragonite; XVIII, Euphyllite; XIX, Jefferisite; XX, Chlorite; XXI, Kerrite (a new mineral); XXII, Maconite (a new mineral); XXIII, Willcoxite (a new mineral); XXIV, Pattersonite; XXV, Chloritoid; XXVI, Margarite; XXVII, an earthy mineral from Gainesville, Georgia; XXVIII, Dudleyite (a new species), and XXIX, Lazulite.

The conclusions reached by Dr. Genth, as the result of this extended investigation, are as follows: (1) at the great period when the chromiferous chrysolite beds were deposited, a large quantity of alumina was separated which formed beds of corundum; (2) this corundum has subsequently been acted on and in this way changed into various mineral species—spinel, fibrolite, cyanite, tourmaline, damourite, chlorite, and margarite, and perhaps also into some varieties of feldspar; (3) a part of the products of the alteration of corundum still exist in the form of large beds of mica (damourite) and chlorite slates or schists; (4) another part has been still farther altered and converted into other minerals and rocks, such as pyrophyllite, paragonite, beauxite, lazulite, etc.

In 1874 Dr. Genth was appointed by Professor Lesley, Director of the Second Geological Survey of Pennsylvania, to the position of chemist and mineralogist to the survey, and toward the close of that year he presented a Preliminary Report on the Mineralogy of Pennsylvania, which, together with an Appendix on Hydrocarbon Compounds, prepared by S. P. Sadtler, covers two hundred and sixty pages. The following year he published a Second Preliminary Report, covering thirty-one pages. He was also chemist to the Board of Agriculture of Pennsylvania, and did much by his investigations, especially by his analysis of fertilizers, to develop the agricultural industry of the State and to maintain a high standard of excellence in all farm products.

As a man of science, Dr. Genth stood among the first in this country. As a chemist, especially in analytical work, he was almost without a peer, being completely familiar, not only with the reactions and methods of determination and separation of the ordinary elemental and compound ions, but, what is more remarkable, of the rarer and less frequently occurring ones as well; but, more than this, his scientific work was characterized by a conscientiousness and fidelity to fact which was exceptional. No labor seemed to him too great if by it an added accuracy could be secured. His knowledge of minerals was complete. Not only did his acute vision aid his early training in recognizing them at a glance, but his skill in detecting their physical and chemical properties gave him remarkable power in recognizing new species. Moreover, his devotion to scientific accuracy was so great that most, if not all, of the discussions he had with others involved questions of fact rather than of opinion. Again, his mind had acquired great facility in grasping the relations of structural grouping, both in salts and minerals, and the rational formula of an ammonia-cobalt base or of a complex mineral species was at once clearly recognized from the empirical results of his analysis.

As a teacher, Dr. Genth was most successful. Apart from his complete command of the subject, he took a great interest in his good students and devoted himself assiduously to their advancement; but for those who were studiously indifferent and careless, to his credit be it said, he had but little regard. He was merciless upon evasive, and especially upon fraudulent, work, particularly in analysis. The reputation which he gave to his department in the university was deservedly high. The large amount of research work which he did was never allowed to interfere with his instruction, and those who were his students remained ever afterward among his best friends. His retirement was a great loss to the university, the more so since there is reason to believe that possibly it might have been avoided.

Professor Dr. Genth was everywhere recognized by his scientific associates as a man of rare talent. He was elected a member of the American Philosophical Society in January, 1854. He was one of the corporate members of the American Chemical Society, and was elected a Vice-President in 1876 and President in 1880. In 1872 he was elected a member of the National Academy of Sciences, and in 1875 a fellow of the American Academy of Arts and Sciences in Boston. The American Association for the Advancement of Science paid him, in 1888, the high compliment of election as one of the three honorary fellows of the association.

Doctor Genth's personality was most agreeable. He was cordial to his friends and associates, valued highly their society, and was ever ready to give them any assistance he could render out of the storehouse of his knowledge. He was twice married, first in Europe, in 1847, to Karolina Jaeger, the daughter of the librarian of Marburg University, by whom he had three children, two sons and a daughter, all of whom are yet living. In 1852 he married Fräulein Minna Paulina Fischer, of Silesian Prussia, whom he met in Cumberland, Maryland; nine children, four daughters and five sons, being the result of this second marriage. Of these four daughters and one son are still living.

Doctor Genth was rather corpulent in his habit, and in his later years went about with some difficulty, being considerably troubled with asthma. He died at his home, in Philadelphia, on the 2d of February, 1893, from an attack of pneumonia, being in his seventy-third year.

NEW MINERALS ESTABLISHED BY F. A. GENTH.

Barnhardtite.
Whitneyite.
Rhombic tungstate of lime.
Melonite.
Calaverite.
Montanite.
Cosalite.
Kerrite.
Maconite.
Willcoxite.
Dudleyite.
Schirmerite.
Psittacinite.
Magnolite.
Endlichite.
Lansfordite.
Nesquehonite.
Aguilarite.
Ferrotellurite.
Phosphuranylite.
Penfieldite.
Coloradoite.
Nickelgymnite (genthite).

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1842. 2. Alter verschiedener Zechsteine. Leonhard-Bronn's N. Jahrbuch, pp. 707, 708.

1842. 3. Prehnit, Pseudomorph nach Analcim. Leonhard-Bronn's N. Jahrbuch, p. 707.

1843. 4. Chemische Untersuchung des Masopin's, eines neuen harzartigen Körpers. Liebig's Annalen, xlvi, pp. 124–128.

1844. 5. Analysen verschiedener Gaarkupfer. Notizenblatt des Goettingischen Vereins Bergmännischer Freunde No. 44.

1845. 6. Tabellarische Uebersicht der wichtigsten Reactionen, welche Basen in ihren Salzen zeigen. Bayrhoffer'sche Universität's Buchhandlung.

1845. 7. Tabellarische Uebersicht der wichtigsten Reactionen, welche Säuren in ihren Salzen zeigen. Bayrhoffer'sche Universität's Buchhandlung.

1845. 8. Allotropische Modification des Nickeloxyduls. Liebig's Annalen, liii, pp. 139–141.

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1848. 10. Untersuchung der Eruptions-producte des Hekla. Liebig's Annalen, lxvi, pp. 13–28.

1848. 11. Eocene Schichten mit Beschreibung der Petrefacten. Leonhard Bronn's N. Jahr., pp. 188–192.

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1848. 13. Untersuchung einiger Mineralien. Liebig's Annalen, lxvi, pp. 270–280.

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   2. Phillipsit vom Stempel bei Marburg.
   3. Chabazit von Annerod bei Giessen.
   4. Eisenmulm von der Grube "Alte Birke" bei Siegen.
   5. Speisskobalt von Riechelsdorf.
   6. Uranit aus dem Siebengebirge.

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1851. 15. Vorläufige Notiz über Gepaarte Kobaltverbindungen. Keller-Tiedemann's Nordamerikanischer Monatsbericht, ii, pp. 8–12.

1851. 16. Chemisch-Mineralogische Notizen. Keller-Tiedemann's N. A. Monatsbericht, ii, pp. 249, 250.

   Platin in Pennsylvanien.
   Tetradymit von Nord Carolina.
   Magnetkies von der Gap Mine.

1851. 17. Aschenbestandtheile des Blutes von Limulus Cyclops. Keller-Tiedemann's N. A. Monatsbericht, iii, pp. 438–441.

1851. 18. Chemisch-Mineralogische Beiträge. Keller-Tiedemann's N. A. Monatsbericht, iii, pp. 486–488.
Henry Wurtz's Methode der Aufschliessung der Silicate.
Orthoclas von Nord Carolina.
Nickelgymnit von Texas, Lancaster Co., Pa.

1852. 19. Untersuchung des Mineralwassers von Bristol, Pa. Keller-Tiedemann's N. A. Monatsbericht iv, pp. 246, 247.

1852. 20. Ueber die Aschenbestandtheile des Blutes von Limulus Cyclops. Liebig's Annalen, lxxxi, pp. 68–73.

1852. 1853. 21. On some minerals which accompany gold in California. Proc. Phila. Ac. Nat. Sci., vi, pp. 113, 114.

1852. 1853. 22. On Strontiano-calcite, a new mineral. Proc. Phila. Ac. Nat. Sci., vi, p. 114.

1852. 1853. 23. On Rhodophyllite, a new mineral. Proc. Phila. Ac. Nat. Sci., vi, pp. 121–124; Am. Jour. Sci., xv, p. 438.

1852. 1853. 24. On a probably new element with Iridosmine and Platinum, in California. Proc. Phila. Ac. Nat. Sci., vi, pp. 209, 210; Am. Jour. Sci., xv, p. 246.

1852. 1853. 25. On a new variety of Gray Copper. Proc. Phila. Ac. Nat. Sci., vi, pp. 296, 297.

1852. 1853. 26. On Owenite, a new mineral. Proc. Phila. Ac. Nat. Sci., vi, pp. 297–299.

1853. 27. On the Allotropic modification of oxide of cobalt. Am. Jour. Sci. (2), xv, p. 120.

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Gray copper. Allanite.

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Kaemmererite.

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1854. 32. Contributions to Mineralogy. Am. Jour. Sci. (2), xviii, pp. 410, 411.
Pyrophyllite. Owenite (identical with Thuringite).
Chrysotile.
Scolecite.

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- Bismuthine.
- Aciculite.
- Barnhardtite, a new mineral.
- Gray Copper.
- Geocronite.
- Garnet.
- Allanite.
- Tungstates of North Carolina.
- Scorodite.
- Wavellite.

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1857. 37. Contributions to Mineralogy. Am. Jour. Sci. (2), xxiii, pp. 415-427.

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- Harrisite (Shepard), a pseudomorph of copper glance after galena.
- Cantonite (Pratt), a pseudomorph of covellite after galena.
- Linnæite.
- Enargite.
- Coracite (Leconte) is Pitchblende.
- Epistilbite.
- Shepard's Plumboresinite is Cyanosite.
- Cherokine (Shepard) is Pyromorphite.
- Vivianite.
- Wavellite.
- Dufrenite.
- Hitchcockite.
- Lanthanite.
- Bismuthite.

1857. 38. A few remarks in answer to Prof. C. U. Shepard's Reply. Am. Jour. Sci. (2), xxiv, p. 133.

1857. 39. Report of Experiments on the Value of Wood Gases, jointly with Wolcott Gibbs. Franklin Inst. Journal, 3d series, vol. 34, p. 126–130.

1858. 40. Analyses of Water from the Dead Sea, and of the Spring of Elisha near Jericho, and virgin soil from near Jerusalem. J. S. Osborn's Palestine, Past and Present.

1858. 41. Preliminary notice of a new base, containing Osmium and the elements of Ammonia, jointly with Wolcott Gibbs. Am. Jour. Sci. (2), xxv, p. 248.

1858. 42. Contributions to Metallurgy, No. 1, Analyses of Chinese coins. Franklin Inst. Journal, xxvi, pp. 261-266.

1859. 43. Contributions to Mineralogy. Am. Jour. Sci. (2), xxvii, p. 400.

- Whitneyite, a new mineral.

1859. 44. Contributions to Mineralogy. Am. Jour. Sci. (2), xxviii, pp. 246–255.

- Native iron.
- Native bismuth.
- Whitneyite.
- Bernhardtite.
- Ripidolite.
- Pholerite.
- Scheelite.
- Rhombic tungstate of lime.

Gersdorffite.
Molybdate of Iron (Owen) is Molybdite.
Albite.
Wolfram.
A few observations on the occurrence of Gold.

1859. 44*a*. Analyse natürlich vorkommender Wasser u. von Erde aus Palästina. Liebig's Ann., cx, 1859, pp. 240, 241.

1860. 45. Reëxamination of Tetradymite from Field's Mine, Ga., and on a new modification of Wolfram. Mining Mag. and Jour. of Geology, i, pp. 358–360.

1861. 46. On Tetradymite; Reply to Dr. Chas. T. Jackson. Journal of Geology, ii, pp. 64–66.

1862. 47. Contributions to Mineralogy. Am. Jour. Sci. (2), xxxiii, pp. 190–206.

Gold, pseudomorphous after aikinite.
Antimonial Arsenic and Arsenolite.
Arsenides of Copper, Domeykite, Algodonite, Whitneyite.
Copper glance, pseudomorphous after galena.
Millerite.
Proustite.
Automolite.
Pyrope.
Lime-Epidote.
Leopardite, a true porphyry.
Staurolite.
Serpentine.
Kerolite.
Monazite.
Rammelsberg's Mineralchemie.

1862. 48. On the Analysis of Chrome Iron ores. Chemical News, vi, pp. 30-33.

1866. 49. On Chrysolite with Chromic Iron in Pennsylvania. Am. Jour. Sci. (2), xli, p. 120.

1868. 50. Contributions to Mineralogy, vii. Am. Jour. Sci. (2), xlv, pp. 305–321.

1. Whitneyite from Arizona.
2. American Tellurium Minerals.
   Petzite and Hessite.
   Altaite.
   Native Tellurium.
   Melonite, a new mineral.
   Calaverite, a new mineral.
   Tetradymite.
   Montanite, a new mineral.
3. Barnhardtite from Arizona.
4. Cosalite, a new mineral.
5. Boulangerite.
6. Tetrahedrite from Arizona.
7. Brochantite.

1868. 51. On the occurrence of cupriferous ores in Texas. Proc. Phila. Ac. Nat. Sci., October 20, 1868, pp. 227, 228.

1870. 52. On American Tin Ores. U. S. R. R. Gazette and Mining Register, May 4, 1870.

1870. 53. On Rhodium Gold from San Domingo and Gold Sands from soil of Phila. Proc. Am. Phil. Soc., xi, pp. 438, 439.

1870. 54. On native lead and iron in Gold Tailings from Montana. Proc. Am. Phil. Soc., xi, pp. 443, 444.

1871. 55. Minerals of North Carolina, December 15, 1871. Published as Appendix C, pp. 53-88, of W. C. Kerr's report on the Geology of North Carolina, i (1875).

1872. 56. Mineral resources of North Carolina. Franklin Inst. Jour., lxiii, pp. 48-61 and 114-130.

1873. 57. Corundum ; its alterations and associated minerals. Proc. Am. Phil. Soc., xiii, pp. 361-406, and in German, Ueber Korund, etc., in Jour. für Prak. Chem., 1874, ix, pp. 49-113.

1874. 58. Reply to Dr. T. Sterry Hunt. Proc. Am. Phil. Soc., July 17, 1874.

1874. 59. Investigation of Iron ores and Limestones from Center, Blair, and Huntingdon Counties, Pa. Proc. Am. Phil. Soc., February 6, 1874.

1874. 60. On American Tellurium and Bismuth Minerals. Proc. Am. Phil. Soc., August 21, 1874, and in German in Jour. für Prak. Chem., N. F., x, pp. 355-369.

Native Tellurium.	Sylvanite.
Tetradymite.	Calaverite.
Altaite.	Tellurate of Copper and Lead.
Hessite.	Bismuthine.
Petzite.	Schirmerite, a new mineral.

1875. 61. Preliminary Report on the Mineralogy of Pennsylvania, "B," of the Second Geological Survey of Pennsylvania, 206 pages.

1875. 62. Second Preliminary Report on the Mineralogy of Pennsylvania, pp. 207-238.

1876. 63. On some American Vanadium Minerals. Am. Jour. Sci. (3), xii, pp. 32-36.

Roscoelite.	Psittacinite, a new mineral.

1877. 64. On some Tellurium and Vanadium Minerals. Proc. Am. Phil. Soc., August 17, 1877, and in German, in Groth's Zeitschrift für Krystallographie, ii, p. 1.

Native Tellurium.	Ferrotellurite, a new mineral.
Hessite.	Roscoelite.
Coloradoite, a new mineral.	Green Mineral from Colorado
Calaverite.	(Aluminous Roscoelite).
Tellurite.	Volborthite.
Magnolite, a new mineral.	

1877. 65. Report on Fertilizers, in First Annual Report of the Pennsylvania Board of Agriculture for 1877, pp. 77-103, with 17 analyses.

1879. 66. On Pyrophyllite from Schuylkill County, Pa. Proc. Am. Phil. Soc., July 18, 1879, pp. 279-280.

1879. 67. South Carolina Phosphates, in Third Annual Report of the Pennsylvania Board of Agriculture for 1879, pp. 20-26.

1879. 68. Examination of North Carolina Uranium Minerals. Am. Chem. Journal, i, pp. 87-93.
Uranotil. Phosphuranylite, a new mineral.
Gummite.

1880. 69. Analyses of Fertilizers, in Fourth Annual Report of the Pennsylvania Board of Agriculture for 1880, pp. 60-73, Nos. 1-62.

1881. 70. On the Valuation of Fertilizers, in Fifth Annual Report of the Pennsylvania Board of Agriculture for 1881, pp. 45-49.

1881. 71. Analyses of Fertilizers, in Fifth Annual Report of the Pennsylvania Board of Agriculture for 1881, pp. 301-304, Nos. 63-191.

1881. 72. Analyses of Minerals and Rocks from Bucks, Montgomery, and Philadelphia Counties, by F. A. Genth and F. A. Genth, Jr., in Report C-6, Second Geological Survey of Pennsylvania, pp. 94-136.

1881. 73. Minerals and Mineral Localities of North Carolina, by F. A. Genth (and W. C. Kerr). Chapter 1 of volume ii of Geology of North Carolina, 1881, 122 pages.

1881. 74. In "Egyptian Obelisks," by Henry Gorringe:
Analysis of the Plagioclase from the Granite of the obelisk, p. 162.
Analysis of the Cement attached to the Pyramidion obelisk, pp. 169, 170.
Analysis of the Bronze from the Crabs of the obelisk, p. 173.
Analysis of the paints on images about 4,000 years old; Yellow and Gilt paint, Black paint, Red paint, pp. 173-175.

1882. 75. On Ensilage, in Sixth Annual Report of the Pennsylvania Board of Agriculture for 1882, pp. 107-109.

1882. 76. Analyses of Fertilizers, Annual Report of the Pennsylvania Board of Agriculture for 1882, pp. 392-394, Nos. 183-301.

1882. 77. Analysis of the Emerald-green Spodumene, "Hiddenite," from North Carolina. Am. Jour. Sci. (3), xxiii, p. 68.

1882. 78. Contributions to Mineralogy. Proc. Am. Phil. Soc., August 18, 1882.
I. 1. Corundum altered into Spinel.
2. Corundum altered into Zoisite.
3. Corundum altered into Feldspar and Mica.
4. Corundum altered into Margarite
5. Corundum altered into Fibrolite.
6. Corundum altered into Cyanite.
7. When were the corundum alterations formed?

II. Alteration of Orthoclase into Albite.
III. Alteration of Talc into Anthophyllite.
IV. Talc, pseudomorph after Magnetite.
V. Gahnite from Mitchell county, N. C.; from Cotopaxi, Col.; by H. F. Keller.
VI. Rutile and Zircon from the Itacolumite of Edge Hill, Bucks county, Pa.
VII. Sphalerite and Prehnite from Cornwall, Lebanon county, Pa.
VIII. Pyrophyllite in Anthracite.
IX. Beryl from Alexander county, N. C.
X. Niccolite from Colorado.
XI. Artificial Alisonite.

1883. 79. On Robert Wilhelm Bunsen in Encyclopædia Americana, i, pp. 675–677.

1883. 80. Analyses of Fertilizers in Seventh Annual Report of Pennsylvania Board of Agriculture for 1883, pp. 365–374, Nos. 300–518 and 86–295.

1884. 81. On Herderite. Proc. Am. Phil. Soc., October 17, 1884.

1885. 82. On the Vanadates and Iodyrite from Lake Valley, N. M., by F. A. Genth and Gerhard vom Rath. Am. Phil. Soc., April 17, 1885, xxii, A, pp. 363–375.

Vanadinite. Descloizite.
Endlichite, a new species. Iodyrite.

1885. 83. Über Vanadate & Jodsilber von Lake Valley, N. M., von F. A. Genth and G. vom Rath. Groth's Zeitschrift, x, 5, pp. 458–487.

1885. 84. Contributions to Mineralogy. Proc. Am. Phil. Soc., October 2, 1885, xxiii, pp. 30–47.

1. Tin and associated minerals.
2. Joseite and Tetradymite.
3. Seleniferous Galenobismutite.
4. Argentobismutite.
5. Cosalite.
6. Schirmerite and Beegerite.
7. Tetrahedrite—Sylvanite.
8. Polybasite.
9. Arsenopyrite and Scorodite.
10. Alteration of Magnesian Limestones from Berks County, Pa.
11. Ilmenite from Carter's Mine, N. C.; Oligoclase.
12. Topaz from Stoneham, Me.
13. Orthoclase from French Creek, Chester County, Pa.
14. Muscovite after Nephelite.
15. Stilpnomelane pseudomorphs—Ankerite.
16. Calamine.

17. Titanite.
18. Vanadinite.
19. Annabergite.
20. Dr. Clemens Winkler & Herderite.

1886. 85. Analysis of pseudomorph from Magnet Cove, Ark., in Geo. F. Kunz Mineralogical Notes. Am. Jour. Sci. (3), xxxi, p. 74, January, 1886.

1886. 86. On an undescribed meteoric Iron from East Tennessee, with two photographic plates. Proc. Ac. Nat. Sci., December 28, 1886.

1887. 87. Contributions to Mineralogy, No. 24. Proc. Am. Phil. Soc., March 18, 1887, with 1 phototype plate and 3 wood cuts.

I. Occurrence of Tin ores in Mexico.

1. On Cassiterite—*a*, C. red variety; *b*, C. yellow variety; *c*, C. pseudomorphs after hematite; *d*, C. pseudomorphs after magnetite.
2. Hematite.
3. Mimetite and M. pseudomorphos after anglesite.

II. Vanadinite and Descloizite.
III. Pyrite pseudomorphous after pyrrhotite.
IV. Hessite.
V. Tapalpite.
VI. Allanite.
VII. Willemite.
VIII. Hisingerite pseudomorphous after calcite.

1888. 88. On Lansfordite, a new mineral. Groth's Zeitschrift.

1889. 89. On Two Minerals from Delaware County, Pa. Proc. Ac. Nat. Sci., 1889, pp. 50-52, with one wood cut.

1. Gahnite.
2. Columbite.

1889. 90. Contributions to Mineralogy, No. 44. Am. Jour. Sci. (3), September, xxxviii, pp. 198–203.

1. Gadolinite from Texas.
2. Cacoclasite.
3. Monazite from Villeneuve, Canada.

1890. 91. Jarosite from Utah. Am. Jour. Sci. (3), xxxix, p. 73, January, 1890.

1890. 92. Contributions to Mineralogy, No. 46. Am. Jour. Sci., xxxix, pp. 47–50; Am. Jour. Sci., January, 1890.

On a new occurrence of corundum in Patrick County, Va.

Corundum.	Muscovite.
Andalusite.	Margarite in part.
Cyanite and Rhætizite	Chloritoid.

1890. 93. On Lansfordite, Nesquehonite, and Pseudomorphs of Nesquehonite, after Lansfordite. By F. A. Genth and S. L. Penfield. Am. Jour. Sci., xxxix, pp. 121–137, February, 1890.

1890. 94. Contributions to Mineralogy, No. 48. Am. Jour. Sci., xl, pp. 114–120.
1. Tetradymite.
2. Pyrite.
3. Quartz, pseudomorphous after Stibnite.
4. Gold in Turquois from Los Cerillos, N. M.
5. Zircon.
6. Scapolite.
7. Garnet.
8. Titaniferous Garnet.
9. Allanite.
10. Lettsomite from Arizona and Utah.

1890. 95. Contributions to Mineralogy, No. 49. With crystallographic notes by S. L. Penfield. Am. Jour. Sci., xl, pp. 199–207.
1. Amarantite.
2. Sideronatrite.
3. Ferronatrite.
4. Utahite.
5. Picropharmacolite from Joplin, Mo.
6. Pitticite.
7. The so-called Gibbsite from Chester County, Pa., a phosphate.
8. Atacamite.

1891. 96. Contributions to Mineralogy, No. 50. With crystallographic notes by S. L. Penfield and L. V. Pirsson. Am. Jour. Sci., May, 1891, xli, pp. 394–400.
1. Three new varieties of Axinite: *a*, from Franklin, N. J.; *b*, Guadalcazar, Mexico; *c*, McKay's Brook, Northumberland County, N. S.
2. Eudialyte from Magnet Cove, Ark.
3. Titanite from Magnet Cove, Ark.
4. Monticellite from Magnet Cove, Ark.

1891. 97. Contributions to Mineralogy, No. 51. Am. Jour. Sci., May, 1891 (3), xli, pp. 401–403.
1. Aguilarite, a new species.
2. Seleniferous Bismuthinite and Guanajuatite.

1891. 98. Minerals of North Carolina. Bulletin No. 74, U. S. Geological Survey.

1891. 99. Contributions to Mineralogy, No. 52. By F. A. Genth, with crystallographic notes by S. L. Penfield. Am. Jour. Sci., xliii, pp. 184–189.
1. Hübnerite.
2. Hessite from Mexico.
3. Bismutite.
4. Natrolite.

1891. 100. On Penfieldite, a new mineral, No. 53, September, 1892. Am. Jour. Sci., xliv, p. 260 (No. 53).

1891. 101. Contributions to Mineralogy, No. 54, November, 1892. Am. Jour. Sci., xliv, pp. 381–389. With crystallographic notes by S. L. Penfield.

1. Aguilarite.
2. Metacinnabarite.
3. Löllingite.
4. Rutile.
5. Quartz resulting from the alteration of Orthoclase, from W. Cheyenne.
6. Danalite.
7. Yttrium-Calcium Fluoride.
8. Altered Zircon or Cyrtolite.
9. Lepidolite.
10. Fuchsite.

1891. 102. On Anglesite, associated with Boléite, No. 55, January, 1893, Am. Jour. Sci., xlv, pp. 32–33.

MEMOIR

OF

JOHN NEWTON.

1823-1895.

BY

CYRUS B. COMSTOCK.

READ BEFORE THE NATIONAL ACADEMY, NOVEMBER 13, 1901.

BIOGRAPHICAL MEMOIR OF GENERAL JOHN NEWTON.

General JOHN NEWTON was born at Norfolk, Virginia, August 24, 1823, and died at New York city May 1, 1895, after a distinguished career as a soldier and as an engineer.

He was the son of Thomas Newton, who represented in Congress the Norfolk district for about thirty years. Entering the Military Academy as a cadet in 1838, he was graduated in 1842, and entered the engineers, remaining an officer of that corps until retired, at his own request, on August 27, 1886.

After leaving West Point he had a varied experience on many works. He became a First Lieutenant in 1852, and previous to that time had served as Assistant to the Board of Engineers, as Assistant Professor of Engineering at the Military Academy, as Assistant Engineer in the construction of Fort Warren, Boston Harbor, and of Fort Trumbull, New London Harbor, and as Superintending Engineer of Construction at Fort Wayne, Michigan, and Forts Porter, Niagara, and Ontario, in New York.

While a First Lieutenant he conducted various surveys for river and harbor improvements in Maine and Florida; was Superintending Engineer of Forts Pulaski and Jackson, of fortifications and light-houses at Pensacola, and was member of a commission to devise a plan for improving the St. Johns River, Florida. He was promoted to Captain July 1, 1856. While a Captain he was the Chief Engineer of the Utah Expedition, Superintending Engineer of Forts Delaware and Mifflin, and member of a special Board of Engineers for modifying plans of fort at Sandy Hook, New York.

The outbreak of the Civil War found him at Fort Delaware, and in 1861 he was Chief Engineer of the Departments of Pennsylvania and Shenandoah; later he was employed in the construction of works for the defense of Alexandria. On September 23, 1861, he was appointed Brigadier General of Volunteers, and served till the close of the war, having been appointed Major General of Volunteers on May 30, 1863. During this war he was engaged in many of its most important battles. In the peninsular campaign his brigade fought at Gaines' Mill, where he received the thanks of the Commanding General, and at Glendale. At Antietam he was heavily engaged, and was brevetted Lieutenant Colonel in the Regular Army for his services. At Fredericksburg he was on the left of the line at Franklin's Crossing. In the Chancellorsville campaign he remained with Sedgwick and attacked the line of stone wall at the foot of Marye's Heights, where Burnside's attack had been so severely repulsed in 1862. General Newton carried the position, losing in a few minutes 1,000 men out of the 3,500 that could be brought into action.

At Gettysburg, when Gen. John F. Reynolds was killed, General Newton was assigned to the command of the First Corps, and for his services was brevetted Colonel in the Regular Army.

Transferred to General Sherman's army, he served in the Atlanta campaign, in command of the second division of the Fourth Corps, under General Thomas, at the battles of Rocky Face Ridge, Resaca, Kenesaw, Peach Tree Creek, and at the siege of Atlanta.

At the battle of Peach Tree Creek, General Newton asked of Gen. G. H. Thomas permission to occupy a ridge in advance of the creek, which General Newton deemed important, and did so with little resistance. It proved to be a very important point, and the enemy made repeated attempts to carry it and to turn its left flank, but they were all unsuccessful. Gen. G. W. Smith says:

"If Newton had not taken position on the crest of the hills at the time he did, and had not then formed his troops in the manner he did, it is probable the surprise would have been successful. The consequences of such an event would have been, if not the destruction of Thomas' command, the separation of Sherman's forces into two parts, with an active and vigorous enemy between them; if not defeated in detail, it would have been difficult for the separated forces to unite without a long march to the rear. In either event, Atlanta would not probably have been captured, at least during that campaign."

Gen. George H. Thomas, in his report of the battle of Peach Tree Creek, says:

"The left and center advanced to feel the enemy during the afternoon, and while on open ground and unprotected by any works were assaulted furiously, the attack falling first on Newton's division, which gallantly stood its ground, repulsing charge after charge, although his left was very much exposed during the contest."

In the fall of 1864 General Newton was placed in command of the district of Key West and Tortugas, and served there till the close of the war. He received the brevets of Brigadier General, U. S. Army, for services at Peach Tree Creek, and of Major General, U. S. Army, for gallant and meritorious services during the war. He was also brevetted Major General of Volunteers.

In 1866 General Newton was mustered out of the volunteer service and returned to his duties as an officer of engineers. He was stationed at New York city in 1866, where he had charge of numerous works till he become Chief of Engineers in 1884. Besides the works in his charge he was also a member of many important special boards of engineers. Among these were the Board for the Examination of the Delaware Breakwater Harbor of Refuge in 1871, the board on Captain Howell's plan for a ship canal from the Mississippi river to the Gulf of Mexico in 1873, the board for improvement of Galveston harbor in 1875, the board for improvement of entrance to Charleston harbor, and the board to report on the Brooklyn bridge in 1883. He was a member of the Permanent Board of Engineers for fortifications and for river and harbor improvements from 1879 to 1884.

Among the more important of the works under his immediate charge while stationed at New York were the Hudson River and the Hell Gate entrance to New York harbor. In the Hudson River his works increased in an important degree the navigable depth of the river, greatly to the advantage of the enormous commerce carried by it.

At Hell Gate, where the channels were narrow and crooked and the tidal currents violent, navigation was made still more difficult by small rocky islands and shoals and by a rocky point (Hallets Point) which projected from the Long Island shore. Some of the sharp rock peaks whose tops were under water had their heights reduced by Mr. Maillefert's method—that is to say, by exploding masses of gunpowder on their tops. This method, while effecting an increase of depth over sharp points or ridges, failed when tried on any considerable area, and it was necessary to use other means. Beside the ordinary difficulties of blasting under water at depths which might reach 26 feet below low water, violent currents existed at certain stages of the tide, and a drilling apparatus in the water was constantly exposed to being struck by one of the stream of vessels passing through the narrow channel. Two conditions had to be fulfilled: First, a stable position for the drills; second, an adequate protection for them against vessels. The method devised consisted, first, of an iron dome and framework 30 feet in diameter, resting on adjustable legs and carrying 21 vertical tubes properly spaced, through which the drills were operated. This satisfied the first condition. To protect this dome from collisions and to operate the drills, a large and heavy scow was constructed, having a well 32 feet in diameter, through which the dome could be lowered and raised by steam power on the scow, which power also operated the drills. The scow was heavily anchored, and after the dome was lowered into position for drilling was able to resist most collisions. A set of holes having been drilled, the dome was raised from the bottom, the scow was swung aside through a distance varying from 175 to 350 feet from the holes. They were then charged usually with nitroglycerine or one of its compounds and exploded by electricity. The drill-holes were nearly six inches in diameter. This drilling scow was used between 1869 and 1875 to remove Diamond Reef, the Frying Pan, Pot Rock, and Way's Reef.

At Hallets Point, which is a part of the mainland of Long Island, a different method was followed. The area to be removed (about three acres) was in plan nearly a semi-ellipse, with a longer axis of 720 and a shorter axis of 300 feet. A cofferdam was first built extending from the land out below the low-water line, and a shaft following its contour was then sunk to a depth of 33 feet below low water. From this shaft ten principal tunnels radiated so as to cross the area to be removed. Far out from the shaft intermediate tunnels were run, making thirty-five tunnels in all. These tunnels at the shaft were from 17 to 22 feet in height and from 9 to 12¾ feet in width, diminishing rapidly in size in going outward, in consequence of the downward slope of the rock surface. Transverse galleries, ten in number, were excavated, with an interval of about 25 feet between their center lines. These crossed the tunnels approximately at right angles, and the result was, when the rock excavation was completed, that over the area to be removed there was a rock roof supported by the piers formed by the intersections of the tunnels and galleries. Holes were then drilled in the piers and the roof, and were charged with 50,000 pounds of dynamite (or of similar compounds), which was fired simultaneously by electricity after the tunnels had been filled with water. The broken fragments of rock were removed by steam grapples, having first been blasted if necessary.

Flood Rock, also called Middle Reef, was removed in a similar manner, the area to be removed being nine acres, instead of three, as at Hallets Point. There were 21,670 feet of tunnels, whose floors were from 50 to 64 feet below low water. When the rock excavation was completed the rock roof was left supported by 467 pillars, and there were 12,561 charges to be exploded simultaneously. Colonel McFarland and Lieutenant Derby, of the engineers, had made careful investigation of what was called sympathetic explosions, and had found that in water dynamite charges encased in tubes of sheet copper 0.005 inch thick could be certainly fired by 10 pounds of dynamite exploded at a distance of 27 feet. This made it possible to reduce enormously the difficulty of exploding simultaneously about 12,000 charges, since an explosion of 10 pounds of dynamite could be made to fire all holes within 27 feet of it. Accordingly, charges of 10 pounds of dynamite were distributed 25 feet apart, there being in all 591 such charges. These were exploded by electricity, and they fired the other charges by the shock transmitted through the water. The total charge of explosives, principally of racka-rock (a chlorate compound) was about 240,000 pounds. The visible effect was the rising of a mass of water over a large area high in the air, making an imposing spectacle.

Much uneasiness had been expressed lest the explosion of such large charges at Hallets Point and Flood Rock should do serious damage to buildings in the vicinity. To show his entire confidence that no dangerous results would follow, General Newton guided his little daughter's hand at both places to close the electric circuit that caused the explosion. The novelty, on so large a scale, of the methods used added largely to his reputation as an engineer.

On March 6, 1884, General Newton was appointed Chief of Engineers, and from that time till his retirement, at his own request, on August 27, 1886, he faithfully performed the arduous duties which accompany that office.

For two years after his retirement he was Commissioner of

Public Works in New York city, and was President of the Panama Railroad Company from 1888 till his death, May 1, 1895. On May 3, 1895, the Board of Directors of the Panama Railroad Company adopted the following resolution:

"When, in 1888, General John Newton became the President of the Panama Railroad Company, he had earned a name honored by the nation through forty years of distinguished service in its War Department and on the battlefield, as well as by succeeding years of equally honorable duties in civil life.

"During this long career his fame in his loved profession had steadily grown from early manhood without a check, until his preëminence as an engineer who had successfully met every problem confronting him in great governmental works was fully recognized at home and abroad.

"The duties of the office of president of the corporation, the concerns of which are international and of unusual variety in the management of its system of 6,000 miles, required just such talents as General Newton had so conspicuously exhibited, and the corporation was fortunate in securing them in its behalf.

"We give grateful acknowledgment to the rare fidelity, the patient and studious devotion, the far-seeing discernment, and the unwavering adherence to principles which, with a ripe judgment, made his counsels so valued and his administration so successful.

"But we wish to record, as well, our personal affection for one who was to each a personal friend, and whose invariable amiability and courtliness made business associations with him a rare pleasure and brings to each the sense of a personal loss.

"Therefore be it unanimously

"*Resolved*, That this simple expression of our sentiment be engrossed on the records of the corporation, and under the signature of each director be transmitted to the family of General Newton, with the sincere sympathy of the board."

General Newton was elected a member of the National Academy of Sciences in 1885. In 1886 he received the degree of Doctor of Laws from St. Francis Xavier College. He was married to Miss Anna M. Starr, daughter of Jonathan Starr, of New London, in 1848, and left a widow, a daughter, and five sons to mourn his death.

	DATE DUE